[[1514](#_bookmark0)] R¨ottger, Stefan, Alexander Irion, and Thomas Ertl, “Shadow Volumes Revisited,” *Journal of WSCG (10th International Conference in Central Europe on Computer Graphics, Visualiza- tion and Computer Vision)*, vol. 10, no. 1–3, pp. 373–379, Feb. 2002. Cited on p. 232

[[1515](#_bookmark0)] Rougier, Nicolas P., “Higher Quality 2D Text Rendering,” *Journal of Computer Graphics Techniques*, vol. 1, no. 4, pp. 50–64, 2013. Cited on p. 676, 677

[[1516](#_bookmark0)] Rougier, Nicolas P., “Shader-Based Antialiased, Dashed, Stroked Polylines,” *Journal of Com- puter Graphics Techniques*, vol. 2, no. 2, pp. 105–121, 2013. Cited on p. 669

[[1517](#_bookmark0)] de Rousiers, Charles, and Matt Pettineo, “Depth of Field with Bokeh Rendering,” in Patrick Cozzi & Christophe Riccio, eds., *OpenGL Insights*, CRC Press, pp. 205–218, 2012. Cited on p. 531, 536

[[1518](#_bookmark0)] Ruijters, Daniel, Bart M. ter Haar Romeny, and Paul Suetens, “Eﬃcient GPU-Based Texture Interpolation Using Uniform B-Splines,” *Journal of Graphics, GPU, and Game Tools*, vol. 13, no. 4, pp. 61–69, 2008. Cited on p. 180, 733, 734

[[1519](#_bookmark0)] Rusinkiewicz, Szymon, and Marc Levoy, “QSplat: A Multiresolution Point Rendering Sys- tem for Large Meshes,” in *SIGGRAPH ’00: Proceedings of the 27th Annual Conference on Computer Graphics and Interactive Techniques*, ACM Press/Addison-Wesley Publishing Co., pp. 343–352, July 2000. Cited on p. 573

[[1520](#_bookmark0)] Rusinkiewicz, Szymon, Michael Burns, and Doug DeCarlo, “Exaggerated Shading for Depict- ing Shape and Detail,” *ACM Transactions on Graphics*, vol. 25, no. 3, pp. 1199–1205, July 2006. Cited on p. 654

[[1521](#_bookmark0)] Rusinkiewicz, Szymon, Forrester Cole, Doug DeCarlo, and Adam Finkelstein, *SIGGRAPH Line Drawings from 3D Models course*, Aug. 2008. Cited on p. 656, 678

[[1522](#_bookmark0)] Ruskin, Elan, “Streaming Sunset Overdrive’s Open World,” *Game Developers Conference*,

Mar. 2015. Cited on p. 871

[[1523](#_bookmark0)] Ryu, David, “500 Million and Counting: Hair Rendering on *Ratatouille*,” Pixar Technical Memo 07-09, May 2007. Cited on p. 648

[[1524](#_bookmark0)] “S3TC DirectX 6.0 Standard Texture Compression,” *S3 Inc.* website, 1998. Cited on p. 192

[[1525](#_bookmark0)] Sadeghi, Iman, Heather Pritchett, Henrik Wann Jensen, and Rasmus Tamstorf, “An Artist Friendly Hair Shading System,” in *ACM SIGGRAPH 2010 Papers*, ACM, article no. 56, July 2010. Cited on p. 359, 644

[[1526](#_bookmark0)] Sadeghi, Iman, Oleg Bisker, Joachim De Deken, and Henrik Wann Jensen, “A Practical Microcylinder Appearance Model for Cloth Rendering,” *ACM Transactions on Graphics*, vol. 32, no. 2, pp. 14:1–14:12, Apr. 2013. Cited on p. 359

[[1527](#_bookmark0)] Safdar, Muhammad, Guihua Cui, Youn Jin Kim, and Ming Ronnier Luo, “Perceptually Uni- form Color Space for Image Signals Including High Dynamic Range and Wide Gamut,” *Optics Express*, vol. 25, no. 13, pp. 15131–15151, June 2017. Cited on p. 276

[[1528](#_bookmark0)] Saito, Takafumi, and Tokiichiro Takahashi, “Comprehensible Rendering of 3-D Shapes,” *Com- puter Graphics (SIGGRAPH ’90 Proceedings)*, vol. 24, no. 4, pp. 197–206, Aug. 1990. Cited

on p. 661, 883, 884

[[1529](#_bookmark0)] Salvi, Marco, “Rendering Filtered Shadows with Exponential Shadow Maps,” in Wolfgang Engel, ed., *ShaderX*6, Charles River Media, pp. 257–274, 2008. Cited on p. 256

[[1530](#_bookmark0)] Salvi, Marco, “Probabilistic Approaches to Shadow Maps Filtering,” *Game Developers Con- ference*, Feb. 2008. Cited on p. 256

[[1531](#_bookmark0)] Salvi, Marco, Kiril Vidim˘ce, Andrew Lauritzen, and Aaron Lefohn, “Adaptive Volumetric Shadow Maps,” *Computer Graphics Forum*, vol. 29, no. 4, pp. 1289–1296, 2010. Cited on p. 258, 570

[[1532](#_bookmark0)] Salvi, Marco, and Karthik Vaidyanathan, “Multi-layer Alpha Blending,” in *Proceedings of the 18th ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games*, ACM, pp. 151– 158, 2014. Cited on p. 156, 642

[[1533](#_bookmark0)] Salvi, Marco, “An Excursion in Temporal Supersampling,” *Game Developers Conference*,

Mar. 2016. Cited on p. 143

[[1534](#_bookmark0)] Salvi, Marco, “Deep Learning: The Future of Real-Time Rendering?,” *SIGGRAPH Open Problems in Real-Time Rendering course*, Aug. 2017. Cited on p. 1043

[[1535](#_bookmark0)] Samet, Hanan, *Applications of Spatial Data Structures: Computer Graphics, Image Process- ing and GIS*, Addison-Wesley, 1989. Cited on p. 825

[[1536](#_bookmark0)] Samet, Hanan, *The Design and Analysis of Spatial Data Structures*, Addison-Wesley, 1989.

Cited on p. 825

[[1537](#_bookmark0)] Samosky, Joseph, *SectionView: A System for Interactively Specifying and Visualizing Sec- tions through Three-Dimensional Medical Image Data*, MSc thesis, Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology, 1993. Cited on p. 969

[[1538](#_bookmark0)] Sanchez, Bonet, Jose Luis, and Tomasz Stachowiak, “Solving Some Common Problems in a Modern Deferred Rendering Engine,” *Develop* conference, July 2012. Cited on p. 570

[[1539](#_bookmark0)] Sander, Pedro V., Xianfeng Gu, Steven J. Gortler, Hugues Hoppe, and John Snyder, “Silhou- ette Clipping,” in *SIGGRAPH ’00: Proceedings of the 27th Annual Conference on Computer Graphics and Interactive Techniques*, ACM Press/Addison-Wesley Publishing Co., pp. 327– 334, July 2000. Cited on p. 667

[[1540](#_bookmark0)] Sander, Pedro V., John Snyder, Steven J. Gortler, and Hugues Hoppe, “Texture Mapping Pro- gressive Meshes,” in *SIGGRAPH ’01 Proceedings of the 28th Annual Conference on Computer Graphics and Interactive Techniques*, ACM, pp. 409–416, Aug. 2001. Cited on p. 710

[[1541](#_bookmark0)] Sander, Pedro V., David Gosselin, and Jason L. Mitchell, “Real-Time Skin Rendering on Graphics Hardware,” in *ACM SIGGRAPH 2004 Sketches*, ACM, p. 148, Aug. 2004. Cited on p. 635

[[1542](#_bookmark0)] Sander, Pedro V., Natalya Tatarchuk, and Jason L. Mitchell, “Explicit Early-Z Culling for Eﬃcient Fluid Flow Simulation,” in Wolfgang Engel, ed., *ShaderX*5, Charles River Media, pp. 553–564, 2006. Cited on p. 53, 1016

[[1543](#_bookmark0)] Sander, Pedro V., and Jason L. Mitchell, “Progressive Buﬀers: View-Dependent Geometry and Texture LOD Rendering,” *SIGGRAPH Advanced Real-Time Rendering in 3D Graphics and Games course*, Aug. 2006. Cited on p. 860

[[1544](#_bookmark0)] Sander, Pedro V., Diego Nehab, and Joshua Barczak, “Fast Triangle Reordering for Vertex Locality and Reduced Overdraw,” *ACM Transactions on Graphics*, vol. 26, no. 3, pp. 89:1– 89:9, 2007. Cited on p. 701

[[1545](#_bookmark0)] Sathe, Rahul P., “Variable Precision Pixel Shading for Improved Power Eﬃciency,” in Eric Lengyel, ed., *Game Engine Gems 3*, CRC Press, pp. 101–109, 2016. Cited on p. 814

[[1546](#_bookmark0)] Scandolo, Leonardo, Pablo Bauszat, and Elmar Eisemann, “Merged Multiresolution Hierar- chies for Shadow Map Compression,” *Computer Graphics Forum*, vol. 35, no. 7, pp. 383–390, 2016. Cited on p. 264

[[1547](#_bookmark0)] Sch¨afer, H., J. Raab, B. Keinert, M. Meyer, M. Stamminger, and M. Nießner, “Dynamic Feature-Adaptive Subdivision,” in *Proceedings of the 19th Symposium on Interactive 3D Graphics and Games*, ACM, pp. 31–38, 2014. Cited on p. 779

[[1548](#_bookmark0)] Schander, Thomas, and Clemens Musterle, “Real-Time Path Tracing Using a Hybrid Deferred Approach,” *GPU Technology Conference*, Oct. 18, 2017. Cited on p. 510

[[1549](#_bookmark0)] Schauﬂer, G., and W. Stu¨rzlinger, “A Three Dimensional Image Cache for Virtual Reality,”

*Computer Graphics Forum*, vol. 15, no. 3, pp. 227–236, 1996. Cited on p. 561, 562

[[1550](#_bookmark0)] Schauﬂer, Gernot, “Nailboards: A Rendering Primitive for Image Caching in Dynamic Scenes,” in *Rendering Techniques ’97*, Springer, pp. 151–162, June 1997. Cited on p. 564, 565

[[1551](#_bookmark0)] Schauﬂer, Gernot, “Per-Object Image Warping with Layered Impostors,” in *Rendering Tech- niques ’98*, Springer, pp. 145–156, June–July 1998. Cited on p. 565

[[1552](#_bookmark0)] Scheib, Vincent, “Parallel Rendering with DirectX Command Buﬀers,” *Beautiful Pixels* blog,

July 22, 2008. Cited on p. 814

[[1553](#_bookmark0)] Scheiblauer, Claus, *Interactions with Gigantic Point Clouds*, PhD thesis, Vienna University of Technology, 2016. Cited on p. 575

[[1554](#_bookmark0)] Schertenleib, Sebastien, “A Multithreaded 3D Renderer,” in Eric Lengyel, ed., *Game Engine Gems*, Jones and Bartlett, pp. 139–147, 2010. Cited on p. 814

[[1555](#_bookmark0)] Scherzer, Daniel, “Robust Shadow Maps for Large Environments,” *Central European Seminar on Computer Graphics*, May 2005. Cited on p. 242

[[1556](#_bookmark0)] Scherzer, D., S. Jeschke, and M. Wimmer, “Pixel-Correct Shadow Maps with Temporal Re- projection and Shadow Test Conﬁdence,” in *Proceedings of the 18th Eurographics Symposium on Rendering Techniques*, Eurographics Association, pp. 45–50, 2007. Cited on p. 522, 523

[[1557](#_bookmark0)] Scherzer, D., and M. Wimmer, “Frame Sequential Interpolation for Discrete Level-of-Detail Rendering,” *Computer Graphics Forum*, vol. 27, no. 4, 1175–1181, 2008. Cited on p. 856

[[1558](#_bookmark0)] Scherzer, Daniel, Michael Wimmer, and Werner Purgathofer, “A Survey of Real-Time Hard Shadow Mapping Methods,” *Computer Graphics Forum*, vol. 30, no. 1, pp. 169–186, 2011.

Cited on p. 265

[[1559](#_bookmark0)] Scherzer, D., L. Yang, O. Mattausch, D. Nehab, P. Sander, M. Wimmer, and E. Eisemann, “A Survey on Temporal Coherence Methods in Real-Time Rendering,” *Computer Graphics Forum*, vol. 31, no. 8, pp. 2378–2408, 2011. Cited on p. 523

[[1560](#_bookmark0)] Scheuermann, Thorsten, “Practical Real-Time Hair Rendering and Shading,” in *ACM SIG-*

*GRAPH 2004 Sketches*, ACM, p. 147, Aug. 2004. Cited on p. 641, 644, 645

[[1561](#_bookmark0)] Schied, Christoph, and Carsten Dachsbacher, “Deferred Attribute Interpolation for Memory- Eﬃcient Deferred Shading,” in *Proceedings of the 7th Conference on High-Performance Graphics*, ACM, pp. 43–49, Aug. 2015. Cited on p. 907

[[1562](#_bookmark0)] Schied, Christoph, and Carsten Dachsbacher, “Deferred Attribute Interpolation Shading,” in Wolfgang Engel, ed., *GPU Pro*7, CRC Press, pp. 83–96, 2016. Cited on p. 907

[[1563](#_bookmark0)] Schied, Christoph, Anton Kaplanyan, Chris Wyman, Anjul Patney, Chakravarty R. Alla Chai- tanya, John Burgess, Shiqiu Liu, Carsten Dachsbacher, and Aaron Lefohn, “Spatiotemporal Variance-Guided Filtering: Real-Time Reconstruction for Path-Traced Global Illumination,”

*High Performance Graphics*, July 2017. Cited on p. 511

[[1564](#_bookmark0)] Schilling, Andreas, G. Knittel, and Wolfgang Straßer, “Texram: A Smart Memory for Textur- ing,” *IEEE Computer Graphics and Applications*, vol. 16, no. 3, pp. 32–41, May 1996. Cited on p. 189

[[1565](#_bookmark0)] Schilling, Andreas, “Antialiasing of Environment Maps,” *Computer Graphics Forum*, vol. 20, no. 1, pp. 5–11, 2001. Cited on p. 372

[[1566](#_bookmark0)] Schlag, John, “Using Geometric Constructions to Interpolate Orientations with Quaternions,” in James Arvo, ed., *Graphics Gems II*, Academic Press, pp. 377–380, 1991. Cited on p. 102

[[1567](#_bookmark0)] Schlag, John, “Fast Embossing Eﬀects on Raster Image Data,” in Paul S. Heckbert, ed.,

*Graphics Gems IV*, Academic Press, pp. 433–437, 1994. Cited on p. 211

[[1568](#_bookmark0)] Schlick, Christophe, “An Inexpensive BRDF Model for Physically Based Rendering,” *Com- puter Graphics Forum*, vol. 13, no. 3, pp. 149–162, 1994. Cited on p. 320, 351

[[1569](#_bookmark0)] Schmalstieg, Dieter, and Robert F. Tobler, “Fast Projected Area Computation for Three- Dimensional Bounding Boxes,” *journal of graphics tools*, vol. 4, no. 2, pp. 37–43, 1999. Also collected in [112]. Cited on p. 863

[[1570](#_bookmark0)] Schmalstieg, Dieter, and Tobias Hollerer, *Augmented Reality: Principles and Practice*,

Addison-Wesley, 2016. Cited on p. 917, 940

[[1571](#_bookmark0)] Schmittler, J. I. Wald, and P. Slusallek, “SaarCOR: A Hardware Architecture for Ray Trac- ing,” in *Graphics Hardware 2002*, Eurographics Association, pp. 27–36, Sept. 2002. Cited on p. 1039

[[1572](#_bookmark0)] Schneider, Andrew, and Nathan Vos, “*Nubis*: Authoring Realtime Volumetric Cloudscapes with the *Decima* Engine,” *SIGGRAPH Advances in Real-Time Rendering in Games course*,

Aug. 2017. Cited on p. 619, 620

[[1573](#_bookmark0)] Schneider, Jens, and Ru¨diger Westermann, “GPU-Friendly High-Quality Terrain Rendering,”

*Journal of WSCG*, vol. 14, no. 1-3, pp. 49–56, 2006. Cited on p. 879

[[1574](#_bookmark0)] Schneider, Philip, and David Eberly, *Geometric Tools for Computer Graphics*, Morgan Kauf- mann, 2003. Cited on p. 685, 686, 716, 950, 966, 981, 987, 991

[[1575](#_bookmark0)] Schollmeyer, Andre, Andrey Babanin, and Bernd Fro, “Order-Independent Transparency for Programmable Deferred Shading Pipelines,” *Computer Graphics Forum*, vol. 34, no. 7, pp. 67– 76, 2015. Cited on p. 887

[[1576](#_bookmark0)] Schorn, Peter, and Frederick Fisher, “Testing the Convexity of Polygon,” in Paul S. Heckbert, ed., *Graphics Gems IV*, Academic Press, pp. 7–15, 1994. Cited on p. 686

[[1577](#_bookmark0)] Schott, Mathias, Vincent Pegoraro, Charles Hansen, K´evin Boulanger, and Kadi Bouatouch, “A Directional Occlusion Shading Model for Interactive Direct Volume Rendering,” in *Euro-*

*Vis’09*, Eurographics Association, pp. 855–862, 2009. Cited on p. 607

[[1578](#_bookmark0)] Schott, Mathias, A. V. Pascal Grosset, Tobias Martin, Vincent Pegoraro, Sean T. Smith, and Charles D. Hansen, “Depth of Field Eﬀects for Interactive Direct Volume Rendering,”

*Computer Graphics Forum*, vol. 30, no. 3, pp. 941–950, 2011. Cited on p. 607

[[1579](#_bookmark0)] Schr¨oder, Peter, and Wim Sweldens, “Spherical Wavelets: Eﬃciently Representing Functions on the Sphere,” in *SIGGRAPH ’95: Proceedings of the 22nd Annual Conference on Computer Graphics and Interactive Techniques*, ACM, pp. 161–172, Aug. 1995. Cited on p. 402

[[1580](#_bookmark0)] Schr¨oder, Peter, “What Can We Measure?” *SIGGRAPH Discrete Differential Geometry course*, Aug. 2006. Cited on p. 954

[[1581](#_bookmark0)] Schroders, M. F. A., and R. V. Gulik, “Quadtree Relief Mapping,” in *Graphics Hardware 2006*, Eurographics Association, pp. 61–66, Sept. 2006. Cited on p. 220

[[1582](#_bookmark0)] Schroeder, Tim, “Collision Detection Using Ray Casting,” *Game Developer*, vol. 8, no. 8, pp. 50–56, Aug. 2001. Cited on p. 976

[[1583](#_bookmark0)] Schuetz, Markus, *Potree: Rendering Large Point Clouds in Web Browsers*, Diploma thesis in Visual Computing, Vienna University of Technology, 2016. Cited on p. 574, 575, 576

[[1584](#_bookmark0)] Schu¨ler, Christian, “Normal Mapping without Precomputed Tangents,” in Wolfgang Engel, ed., *ShaderX*5, Charles River Media, pp. 131–140, 2006. Cited on p. 210

[[1585](#_bookmark0)] Schu¨ler, Christian, “Multisampling Extension for Gradient Shadow Maps,” in Wolfgang Engel, ed., *ShaderX*5, Charles River Media, pp. 207–218, 2006. Cited on p. 250

[[1586](#_bookmark0)] Schu¨ler, Christian, “An Eﬃcient and Physically Plausible Real Time Shading Model,” in Wolfgang Engel, ed., *ShaderX*7, Charles River Media, pp. 175–187, 2009. Cited on p. 325

[[1587](#_bookmark0)] Schu¨ler, Christian, “An Approximation to the Chapman Grazing-Incidence Function for At- mospheric Scattering,” in Wolfgang Engel, ed., *GPU Pro*3, CRC Press, pp. 105–118, 2012. Cited on p. 616

[[1588](#_bookmark0)] Schu¨ler, Christian, “Branchless Matrix to Quaternion Conversion,” *The Tenth Planet* blog,

Aug. 7, 2012. Cited on p. 81

[[1589](#_bookmark0)] Schulz, Nicolas, “Moving to the Next Generation—The Rendering Technology of *Ryse*,” *Game Developers Conference*, Mar. 2014. Cited on p. 371, 506, 892, 893, 904

[[1590](#_bookmark0)] Schulz, Nicolas, and Theodor Mader, “Rendering Techniques in *Ryse: Son of Rome*,” *SIG- GRAPH Advances in Real-Time Rendering in Games course*, Aug. 2014. Cited on p. 234, 245, 246, 251, 252, 569, 864

[[1591](#_bookmark0)] Schulz, Nicolas, *CRYENGINE Manual*, Crytek GmbH, 2016. Cited on p. 111, 113, 631

[[1592](#_bookmark0)] Schumacher, Dale A., “General Filtered Image Rescaling,” in David Kirk, ed., *Graphics Gems III*, Academic Press, pp. 8–16, 1992. Cited on p. 184

[[1593](#_bookmark0)] Schwarz, Michael, and Marc Stamminger, “Bitmask Soft Shadows,” *Computer Graphics Fo- rum*, vol. 26, no. 3, pp. 515–524, 2007. Cited on p. 252

[[1594](#_bookmark0)] Schwarz, Michael, and Hans-Peter Seidel, “Fast Parallel Surface and Solid Voxelization on GPUs,” *ACM Transactions on Graphics*, vol. 29, no. 6, pp. 179:1–179:10, Dec. 2010. Cited on p. 581

[[1595](#_bookmark0)] Schwarz, Michael, “Practical Binary Surface and Solid Voxelization with Direct3D 11,” in Wolfgang Engel, ed., *GPU Pro*3, CRC Press, pp. 337–352, 2012. Cited on p. 581, 582

[[1596](#_bookmark0)] Seetzen, Helge, Wolfgang Heidrich, Wolfgang Stuerzlinger, Greg Ward, Lorne Whitehead, Matthew Trentacoste, Abhijeet Ghosh, and Andrejs Vorozcovs, “High Dynamic Range Display Systems,” *ACM Transactions on Graphics (SIGGRAPH 2004)*, vol. 23, no. 3, pp. 760–768,

Aug. 2004. Cited on p. 1011

[[1597](#_bookmark0)] Segal, M., C. Korobkin, R. van Widenfelt, J. Foran, and P. Haeberli, “Fast Shadows and Lighting Eﬀects Using Texture Mapping,” *Computer Graphics (SIGGRAPH ’92 Proceedings)*, vol. 26, no. 2, pp. 249–252, July 1992. Cited on p. 173, 221, 229

[[1598](#_bookmark0)] Segal, Mark, and Kurt Akeley, *The OpenGL Graphics System: A Specification (Version 4.5)*, The Khronos Group, June 2017. Editor (v1.1): Chris Frazier; Editor (v1.2–4.5): Jon Leech;

Editor (v2.0): Pat Brown. Cited on p. 845, 1033

[[1599](#_bookmark0)] Seiler, L. D. Carmean, E. Sprangle, T. Forsyth, M. Abrash, P. Dubey, S. Junkins, A. Lake,

J. Sugerman, R. Cavin, R. Espasa, E. Grochowski, T. Juan, and P. Hanrahan, “Larrabee: A Many-Core x86 Architecture for Visual Computing,” *ACM Transactions on Graphics*, vol. 27, no. 3, pp. 18:1–18:15, 2008. Cited on p. 230, 996, 1017

[[1600](#_bookmark0)] Sekulic, Dean, “Eﬃcient Occlusion Culling,” in Randima Fernando, ed., *GPU Gems*, Addison-

Wesley, pp. 487–503, 2004. Cited on p. 524, 836

[[1601](#_bookmark0)] Selan, Jeremy, “Using Lookup Tables to Accelerate Color Transformations,” in Matt Pharr, ed., *GPU Gems 2*, Addison-Wesley, pp. 381–408, 2005. Cited on p. 289, 290

[[1602](#_bookmark0)] Selan, Jeremy, “Cinematic Color: From Your Monitor to the Big Screen,” VES White Paper, 2012. Cited on p. 166, 283, 289, 290, 291

[[1603](#_bookmark0)] Selgrad, K., C. Dachsbacher, Q. Meyer, and M. Stamminger, “Filtering Multi-Layer Shadow Maps for Accurate Soft Shadows,” *Computer Graphics Forum*, vol. 34, no. 1, pp. 205–215, 2015. Cited on p. 259

[[1604](#_bookmark0)] Selgrad, K., J. Mu¨ller, C. Reintges, and M. Stamminger, “Fast Shadow Map Rendering for Many-Lights Settings,” in *Eurographics Symposium on Rendering—Experimental Ideas & Implementations*, Eurographics Association, pp. 41–47, 2016. Cited on p. 247

[[1605](#_bookmark0)] Sellers, Graham, Patrick Cozzi, Kevin Ring, Emil Persson, Joel da Vahl, and J. M. P. van Waveren, *SIGGRAPH Rendering Massive Virtual Worlds course*, July 2013. Cited on p. 102, 868, 874, 875, 876, 879

[[1606](#_bookmark0)] Sellers, Graham, Richard S. Wright Jr., and Nicholas Haemel, *OpenGL Superbible: Compre- hensive Tutorial and Reference*, Seventh Edition, Addison-Wesley, 2015. Cited on p. 55

[[1607](#_bookmark0)] Sen, Pradeep, Mike Cammarano, and Pat Hanrahan, “Shadow Silhouette Maps,” *ACM Trans- actions on Graphics (SIGGRAPH 2003)*, vol. 22, no. 3, pp. 521–526, 2003. Cited on p. 259

[[1608](#_bookmark0)] Senior, Andrew, “Facial Animation for Mobile GPUs,” in Wolfgang Engel, ed., *ShaderX*7,

Charles River Media, pp. 561–570, 2009. Cited on p. 90

[[1609](#_bookmark0)] Senior, Andrew, “iPhone 3GS Graphics Development and Optimization Strategies,” in Wolf- gang Engel, ed., *GPU Pro*, A K Peters, Ltd., pp. 385–395, 2010. Cited on p. 702, 795, 804, 805

[[1610](#_bookmark0)] Seymour, Mike, “Manuka: Weta Digital’s New Renderer,” *fxguide*, Aug. 6, 2014. Cited on p. 280

[[1611](#_bookmark0)] Shade, J., Steven Gortler, Li-Wei He, and Richard Szeliski, “Layered Depth Images,” in *SIGGRAPH ’98: Proceedings of the 25th Annual Conference on Computer Graphics and Interactive Techniques*, ACM, pp. 231–242, July 1998. Cited on p. 565

[[1612](#_bookmark0)] Shamir, Ariel, “A survey on Mesh Segmentation Techniques,” *Computer Graphics Forum*, vol. 27, no. 6, pp. 1539–1556, 2008. Cited on p. 683

[[1613](#_bookmark0)] Shankel, Jason, “Rendering Distant Scenery with Skyboxes,” in Mark DeLoura, ed., *Game Programming Gems 2*, Charles River Media, pp. 416–420, 2001. Cited on p. 548

[[1614](#_bookmark0)] Shankel, Jason, “Fast Heightﬁeld Normal Calculation,” in Dante Treglia, ed., *Game Program- ming Gems 3*, Charles River Media, pp. 344–348, 2002. Cited on p. 695

[[1615](#_bookmark0)] Shanmugam, Perumaal, and Okan Arikan, “Hardware Accelerated Ambient Occlusion Tech- niques on GPUs,” in *Proceedings of the 2007 Symposium on Interactive 3D Graphics and Games*, ACM, pp. 73–80, 2007. Cited on p. 458

[[1616](#_bookmark0)] Shastry, Anirudh S., “High Dynamic Range Rendering,” *GameDev.net*, 2004. Cited on p. 527

[[1617](#_bookmark0)] Sheﬀer, Alla, Bruno L´evy, Maxim Mogilnitsky, and Alexander Bogomyakov, “ABF++: Fast and Robust Angle Based Flattening,” *ACM Transactions on Graphics*, vol. 24, no. 2, pp. 311– 330, 2005. Cited on p. 485

[[1618](#_bookmark0)] Shemanarev, Maxim, “Texts Rasterization Exposures,” *The AGG Project*, July 2007. Cited on p. 676

[[1619](#_bookmark0)] Shen, Hao, Pheng Ann Heng, and Zesheng Tang, “A Fast Triangle-Triangle Overlap Test Using Signed Distances,” *journals of graphics tools*, vol. 8, no. 1, pp. 17–24, 2003. Cited on p. 974

[[1620](#_bookmark0)] Shen, Li, Jieqing Feng, and Baoguang Yang, “Exponential Soft Shadow Mapping,” *Computer Graphics Forum*, vol. 32, no. 4, pp. 107–116, 2013. Cited on p. 257

[[1621](#_bookmark0)] Shene, Ching-Kuang, “Computing the Intersection of a Line and a Cylinder,” in Paul S.

Heckbert, ed., *Graphics Gems IV*, Academic Press, pp. 353–355, 1994. Cited on p. 959

[[1622](#_bookmark0)] Shene, Ching-Kuang, “Computing the Intersection of a Line and a Cone,” in Alan Paeth, ed.,

*Graphics Gems V*, Academic Press, pp. 227–231, 1995. Cited on p. 959

[[1623](#_bookmark0)] Sherif, Tarek, “WebGL 2 Examples,” *GitHub* repository, Mar. 17, 2017. Cited on p. 122, 125

[[1624](#_bookmark0)] Shewchuk, Jonathan Richard, “Adaptive Precision Floating-Point Arithmetic and Fast Robust Geometric Predicates, *Discrete and Computational Geometry*, vol. 18, no. 3, pp. 305–363, Oct. 1997. Cited on p. 974

[[1625](#_bookmark0)] Shilov, Anton, Yaroslav Lyssenko, and Alexey Stepin, “Highly Deﬁned: ATI Radeon HD 2000 Architecture Review,” *Xbit Laboratories* website, Aug. 2007. Cited on p. 142

[[1626](#_bookmark0)] Shirley, Peter, *Physically Based Lighting Calculations for Computer Graphics*, PhD thesis, University of Illinois at Urbana Champaign, Dec. 1990. Cited on p. 143, 351

[[1627](#_bookmark0)] Shirley, Peter, Helen Hu, Brian Smits, and Eric Lafortune, “A Practitioners’ Assessment of Light Reﬂection Models,” in *Pacific Graphics ’97*, IEEE Computer Society, pp. 40–49, Oct. 1997. Cited on p. 351

[[1628](#_bookmark0)] Shirley, Peter, *Ray Tracing in One Weekend*, Ray Tracing Minibooks Book 1, 2016. Cited on p. 512, 1047

[[1629](#_bookmark0)] Shirley, Peter, “New Simple Ray-Box Test from Andrew Kensler,” *Pete Shirley’s Graphics Blog*, Feb. 14, 2016. Cited on p. 961

[[1630](#_bookmark0)] Shirman, Leon A., and Salim S. Abi-Ezzi, “The Cone of Normals Technique for Fast Processing of Curved Patches,” *Computer Graphics Forum*, vol. 12, no. 3, pp. 261–272, 1993. Cited on p. 833

[[1631](#_bookmark0)] Shishkovtsov, Oles, “Deferred Shading in *S.T.A.L.K.E.R.*,” in Matt Pharr, ed., *GPU Gems* [*2*](#_bookmark0), Addison-Wesley, pp. 143–166, 2005. Cited on p. 216, 888

[[1632](#_bookmark0)] Shodhan, Shalin, and Andrew Willmott, “Stylized Rendering in *Spore*,” in Wolfgang Engel, ed., *GPU Pro*, A K Peters, Ltd., pp. 549–560, 2010. Cited on p. 678

[[1633](#_bookmark0)] Shoemake, Ken, “Animating Rotation with Quaternion Curves,” *Computer Graphics (SIG- GRAPH ’85 Proceedings)*, vol. 19, no. 3, pp. 245–254, July 1985. Cited on p. 73, 76, 80,

82

[[1634](#_bookmark0)] Shoemake, Ken, “Quaternions and 4 4 Matrices,” in James Arvo, ed., *Graphics Gems II*,

×

Academic Press, pp. 351–354, 1991. Cited on p. 80

[[1635](#_bookmark0)] Shoemake, Ken, “Polar Matrix Decomposition,” in Paul S. Heckbert, ed., *Graphics Gems IV*,

Academic Press, pp. 207–221, 1994. Cited on p. 74

[[1636](#_bookmark0)] Shoemake, Ken, “Euler Angle Conversion,” in Paul S. Heckbert, ed., *Graphics Gems IV*,

Academic Press, pp. 222–229, 1994. Cited on p. 70, 73

[[1637](#_bookmark0)] Shopf, J., J. Barczak, C. Oat, and N. Tatarchuk, “March of the Froblins: Simulation and Rendering of Massive Crowds of Intelligent and Details Creatures on GPU,” *SIGGRAPH Advances in Real-Time Rendering in 3D Graphics and Games course*, Aug. 2008. Cited on p. 475, 848, 851

[[1638](#_bookmark0)] Sigg, Christian, and Markus Hadwiger, “Fast Third-Order Texture Filtering,” in Matt Pharr, ed., *GPU Gems 2*, Addison-Wesley, pp. 313–329, 2005. Cited on p. 189, 517

[[1639](#_bookmark0)] Sikachev, Peter, Vladimir Egorov, and Sergey Makeev, “Quaternions Revisited,” in Wolfgang Engel, ed., *GPU Pro*5, CRC Press, pp. 361–374, 2014. Cited on p. 87, 210, 715

[[1640](#_bookmark0)] Sikachev, Peter, and Nicolas Longchamps, “Reﬂection System in *Thief*,” *SIGGRAPH Ad- vances in Real-Time Rendering in Games course*, Aug. 2014. Cited on p. 502

[[1641](#_bookmark0)] Sikachev, Peter, Samuel Delmont, Uriel Doyon, and Jean-Normand Bucci, “Next-Generation Rendering in *Thief*,” in Wolfgang Engel, ed., *GPU Pro*6, CRC Press, pp. 65–90, 2015. Cited on p. 251, 252

[[1642](#_bookmark0)] Sillion, Fran¸cois, and Claude Puech, *Radiosity and Global Illumination*, Morgan Kaufmann, 1994. Cited on p. 442, 483

[[1643](#_bookmark0)] Silvennoinen, Ari, and Ville Timonen, “Multi-Scale Global Illumination in Quantum Break,” *SIGGRAPH Advances in Real-Time Rendering in Games course*, Aug. 2015. Cited on p. 488, 496

[[1644](#_bookmark0)] Silvennoinen, Ari, and Jaakko Lehtinen, “Real-Time Global Illumination by Precomputed Local Reconstruction from Sparse Radiance Probes,” *ACM Transactions on Graphics (SIG-*

*GRAPH Asia 2017)*, vol. 36, no. 6, pp. 230:1–230:13, Nov. 2017. Cited on p. 484

[[1645](#_bookmark0)] Sintorn, Erik, Elmar Eisemann, and Ulf Assarsson, “Sample Based Visibility for Soft Shadows Using Alias-Free Shadow Maps,” *Computer Graphics Forum*, vol. 27, no. 4, pp. 1285–1292, 2008. Cited on p. 261

[[1646](#_bookmark0)] Sintorn, Erik, and Ulf Assarsson, “Hair Self Shadowing and Transparency Depth Ordering Using Occupancy Maps,” in *Proceedings of the 2009 Symposium on Interactive 3D Graphics and Games*, ACM, pp. 67–74, Feb.–Mar. 2009. Cited on p. 645

[[1647](#_bookmark0)] Sintorn, Erik, Viktor K¨ampe, Ola Olsson, and Ulf Assarsson, “Compact Precomputed Vox- elized Shadows,” *ACM Transactions on Graphics*, vol. 33, no. 4, article no. 150, Mar. 2014.

Cited on p. 264, 586

[[1648](#_bookmark0)] Sintorn, Erik, Viktor Ka¨mpe, Ola Olsson, and Ulf Assarsson, “Per-Triangle Shadow Volumes Using a View-Sample Cluster Hierarchy,” in *Proceedings of the 18th Meeting of the ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games*, ACM, pp. 111–118, Mar. 2014. Cited on p. 233, 259

[[1649](#_bookmark0)] Skiena, Steven, *The Algorithm Design Manual*, Springer-Verlag, 1997. Cited on p. 707

[[1650](#_bookmark0)] Skillman, Drew, and Pete Demoreuille, “Rock Show VFX: Bringing Bru¨tal Legend to Life,”

*Game Developers Conference*, Mar. 2010. Cited on p. 569, 572

[[1651](#_bookmark0)] Sloan, Peter-Pike, Jan Kautz, and John Snyder, “Precomputed Radiance Transfer for Real- Time Rendering in Dynamic, Low-Frequency Lighting Environments,” *ACM Transactions on Graphics (SIGGRAPH 2002)*, vol. 21, no. 3, pp. 527–536, July 2002. Cited on p. 471, 479,

480

[[1652](#_bookmark0)] Sloan, Peter-Pike, Jesse Hall, John Hart, and John Snyder, “Clustered Principal Components for Precomputed Radiance Transfer,” *ACM Transactions on Graphics (SIGGRAPH 2003)*, vol. 22, no. 3, pp. 382–391, 2003. Cited on p. 480

[[1653](#_bookmark0)] Sloan, Peter-Pike, Ben Luna, and John Snyder, “Local, Deformable Precomputed Radiance Transfer,” *ACM Transactions on Graphics (SIGGRAPH 2005)*, vol. 24, no. 3, pp. 1216–1224,

Aug. 2005. Cited on p. 431, 481

[[1654](#_bookmark0)] Sloan, Peter-Pike, “Normal Mapping for Precomputed Radiance Transfer,” in *Proceedings of the 2006 Symposium on Interactive 3D Graphics and Games*, ACM, pp. 23–26, 2006. Cited on p. 404

[[1655](#_bookmark0)] Sloan, Peter-Pike, Naga K. Govindaraju, Derek Nowrouzezahrai, and John Snyder, “Image- Based Proxy Accumulation for Real-Time Soft Global Illumination,” in *Pacific Graphics 2007*,

IEEE Computer Society, pp. 97–105, Oct. 2007. Cited on p. 456, 467

[[1656](#_bookmark0)] Sloan, Peter-Pike, “Stupid Spherical Harmonics (SH) Tricks,” *Game Developers Conference*,

Feb. 2008. Cited on p. 395, 400, 401, 428, 429, 430, 431, 470

[[1657](#_bookmark0)] Sloan, Peter-Pike, “Eﬃcient Spherical Harmonic Evaluation,” *Journal of Computer Graphics Techniques*, vol. 2, no. 2, pp. 84–90, 2013. Cited on p. 400

[[1658](#_bookmark0)] Sloan, Peter-Pike, Jason Tranchida, Hao Chen, and Ladislav Kavan, “Ambient Obscurance Baking on the GPU,” in *ACM SIGGRAPH Asia 2013 Technical Briefs*, ACM, article no. 32,

Nov. 2013. Cited on p. 453

[[1659](#_bookmark0)] Sloan, Peter-Pike, “Deringing Spherical Harmonics,” in *SIGGRAPH Asia 2017 Technical Briefs*, ACM, article no. 11, 2017. Cited on p. 401, 429

[[1660](#_bookmark0)] Smedberg, Niklas, and Daniel Wright, “Rendering Techniques in *Gears of War 2*,” *Game Developers Conference*, Mar. 2009. Cited on p. 462

[[1661](#_bookmark0)] Smith, Alvy Ray, *Digital Filtering Tutorial for Computer Graphics*, Technical Memo 27, revised Mar. 1983. Cited on p. 136

[[1662](#_bookmark0)] Smith, Alvy Ray, and James F. Blinn, “Blue Screen Matting,” in *SIGGRAPH ’96: Proceedings of the 23rd Annual Conference on Computer Graphics and Interactive Techniques*, ACM, pp. 259–268, Aug. 1996. Cited on p. 159, 160

[[1663](#_bookmark0)] Smith, Alvy Ray, “The Stuﬀ of Dreams,” *Computer Graphics World*, vol. 21, pp. 27–29, July 1998. Cited on p. 1042

[[1664](#_bookmark0)] Smith, Ashley Vaughan, and Mathieu Einig, “Physically Based Deferred Shading on Mobile,” in Wolfgang Engel, ed., *GPU Pro*7, CRC Press, pp. 187–198, 2016. Cited on p. 903

[[1665](#_bookmark0)] Smith, Bruce G., “Geometrical Shadowing of a Random Rough Surface,” *IEEE Transactions on Antennas and Propagation*, vol. 15, no. 5, pp. 668–671, Sept. 1967. Cited on p. 334

[[1666](#_bookmark0)] Smith, Ryan, “GPU Boost 3.0: Finer-Grained Clockspeed Controls,” Section in “The NVIDIA GeForce GTX 1080 & GTX 1070 Founders Editions Review: Kicking Oﬀ the FinFET Gener- ation,” *AnandTech*, July 20, 2016. Cited on p. 163, 789

[[1667](#_bookmark0)] Smits, Brian E., and Gary W. Meyer, “Newton’s Colors: Simulating Interference Phenomena in Realistic Image Synthesis,” in Kadi Bouatouch & Christian Bouville, eds. *Photorealism in Computer Graphics*, Springer, pp. 185–194, 1992. Cited on p. 363

[[1668](#_bookmark0)] Smits, Brian, “Eﬃciency Issues for Ray Tracing,” *journal of graphics tools*, vol. 3, no. 2, pp. 1–14, 1998. Also collected in [112]. Cited on p. 792, 961

[[1669](#_bookmark0)] Smits, Brian, “Reﬂection Model Design for *WALL-E* and *Up*,” *SIGGRAPH Practical Physi- cally Based Shading in Film and Game Production course*, Aug. 2012. Cited on p. 324

[[1670](#_bookmark0)] Snook, Greg, “Simpliﬁed Terrain Using Interlocking Tiles,” in Mark DeLoura, ed., *Game Programming Gems 2*, Charles River Media, pp. 377–383, 2001. Cited on p. 876

[[1671](#_bookmark0)] Snyder, John, “Area Light Sources for Real-Time Graphics,” Technical Report MSR-TR-96- 11, Microsoft Research, Mar. 1996. Cited on p. 382

[[1672](#_bookmark0)] Snyder, John, and Jed Lengyel, “Visibility Sorting and Compositing without Splitting for Image Layer Decompositions,” in *SIGGRAPH ’98: Proceedings of the 25th Annual Conference on Computer Graphics and Interactive Techniques*, ACM, pp. 219–230, July 1998. Cited on p. 532, 551

[[1673](#_bookmark0)] Soler, Cyril, and Fran¸cois Sillion, “Fast Calculation of Soft Shadow Textures Using Convolu- tion,” in *SIGGRAPH ’98: Proceedings of the 25th Annual Conference on Computer Graphics and Interactive Techniques*, ACM, pp. 321–332, July 1998. Cited on p. 256

[[1674](#_bookmark0)] Sousa, Tiago, “Adaptive Glare,” in Wolfgang Engel, ed., *ShaderX*3, Charles River Media, pp. 349–355, 2004. Cited on p. 288, 527

[[1675](#_bookmark0)] Sousa, Tiago, “Generic Refraction Simulation,” in Matt Pharr, ed., *GPU Gems 2*, Addison-

Wesley, pp. 295–305, 2005. Cited on p. 628

[[1676](#_bookmark0)] Sousa, Tiago, “Vegetation Procedural Animation and Shading in Crysis,” in Hubert Nguyen, ed., *GPU Gems 3*, Addison-Wesley, pp. 373–385, 2007. Cited on p. 639

[[1677](#_bookmark0)] Sousa, Tiago, “Anti-Aliasing Methods in CryENGINE,” *SIGGRAPH Filtering Approaches for Real-Time Anti-Aliasing course*, Aug. 2011. Cited on p. 145, 531

[[1678](#_bookmark0)] Sousa, Tiago, Nickolay Kasyan, and Nicolas Schulz, “Secrets of CryENGINE 3 Graphics Technology,” *SIGGRAPH Advances in Real-Time Rendering in 3D Graphics and Games course*, Aug. 2011. Cited on p. 145, 234, 245, 252, 257, 262, 505

[[1679](#_bookmark0)] Sousa, Tiago, Nickolay Kasyan, and Nicolas Schulz, “CryENGINE 3: Three Years of Work in Review,” in Wolfgang Engel, ed., *GPU Pro*3, CRC Press, pp. 133–168, 2012. Cited on p. 139, 234, 238, 245, 252, 257, 542, 786, 793, 932, 937

[[1680](#_bookmark0)] Sousa, Tiago, Carsten Wenzel, and Chris Raine, “The Rendering Technologies of *Crysis 3*,”

*Game Developers Conference*, Mar. 2013. Cited on p. 887, 889, 890, 895

[[1681](#_bookmark0)] Sousa, Tiago, Nickolay Kasyan, and Nicolas Schulz, “CryENGINE 3: Graphics Gems,” *SIG- GRAPH Advances in Real-Time Rendering in 3D Graphics and Games course*, July 2013.

Cited on p. 531, 535, 539, 540, 542, 604, 888, 892

[[1682](#_bookmark0)] Sousa, T., and J. Geoﬀroy, “*DOOM*: the Devil is in the Details,” *SIGGRAPH Advances in Real-Time Rendering in 3D Graphics and Games course*, July 2016. Cited on p. 569, 629, 883, 901

[[1683](#_bookmark0)] Spencer, Greg, Peter Shirley, Kurt Zimmerman, and Donald Greenberg, “Physically-Based Glare Eﬀects for Digital Images,” in *SIGGRAPH ’95: Proceedings of the 22nd Annual Con- ference on Computer Graphics and Interactive Techniques*, ACM, pp. 325–334, Aug. 1995.

Cited on p. 524

[[1684](#_bookmark0)] Stachowiak, Tomasz, “Stochastic Screen-Space Reﬂections,” *SIGGRAPH Advances in Real-*

*Time Rendering in Games course*, Aug. 2015. Cited on p. 507, 508

[[1685](#_bookmark0)] Stachowiak, Tomasz, “A Deferred Material Rendering System,” online article, Dec. 18, 2015.

Cited on p. 907

[[1686](#_bookmark0)] Stam, Jos, “Multiple Scattering as a Diﬀusion Process,” in *Rendering Techniques ’95*,

Springer, pp. 41–50, June 1995. Cited on p. 634

[[1687](#_bookmark0)] Stam, Jos, “Exact Evaluation of Catmull-Clark Subdivision Surfaces at Arbitrary Parame- ter Values,” in *SIGGRAPH ’98: Proceedings of the 25th Annual Conference on Computer Graphics and Interactive Techniques*, ACM, pp. 395–404, July 1998. Cited on p. 763

[[1688](#_bookmark0)] Stam, Jos, “Diﬀraction Shaders,” in *SIGGRAPH ’99: Proceedings of the 26th Annual Con- ference on Computer Graphics and Interactive Techniques*, ACM Press/Addison-Wesley Pub- lishing Co., pp. 101–110, Aug. 1999. Cited on p. 361

[[1689](#_bookmark0)] Stam, Jos, “Real-Time Fluid Dynamics for Games,” *Game Developers Conference*, Mar. 2003.

Cited on p. 649

[[1690](#_bookmark0)] Stamate, Vlad, “Reduction of Lighting Calculations Using Spherical Harmonics,” in Wolfgang Engel, ed., *ShaderX*3, Charles River Media, pp. 251–262, 2004. Cited on p. 430

[[1691](#_bookmark0)] Stamminger, Marc, and George Drettakis, “Perspective Shadow Maps,” *ACM Transactions on Graphics (SIGGRAPH 2002)*, vol. 21, no. 3, pp. 557–562, July 2002. Cited on p. 241

[[1692](#_bookmark0)] St-Amour, Jean-Fran¸cois, “Rendering *Assassin’s Creed III*,” *Game Developers Conference*,

Mar. 2013. Cited on p. 453

[[1693](#_bookmark0)] Steed, Paul, *Animating Real-Time Game Characters*, Charles River Media, 2002. Cited on

p. 88

[[1694](#_bookmark0)] Stefanov, Nikolay, “Global Illumination in *Tom Clancy’s The Division*,” *Game Developers Conference*, Mar. 2016. Cited on p. 478, 483

[[1695](#_bookmark0)] Steinicke, Frank Steinicke, Gerd Bruder, and Scott Kuhl, “Realistic Perspective Projections for Virtual Objects and Environments,” *ACM Transactions on Graphics*, vol. 30, no. 5, article no. 112, Oct. 2011. Cited on p. 554

[[1696](#_bookmark0)] Stemkoski, Lee, “Bubble Demo,” *GitHub* repository, 2013. Cited on p. 628

[[1697](#_bookmark0)] Stengel, Michael, Steve Grogorick, Martin Eisemann, and Marcus Magnor, “Adaptive Image- Space Sampling for Gaze-Contingent Real-Time Rendering,” *Computer Graphics Forum*, vol. 35, no. 4, pp. 129–139, 2016. Cited on p. 932

[[1698](#_bookmark0)] Sterna, Wojciech, “Practical Gather-Based Bokeh Depth of Field,” in Wolfgang Engel, ed.,

*GPU Zen*, Black Cat Publishing, pp. 217–237, 2017. Cited on p. 535

[[1699](#_bookmark0)] Stewart, A. J., and M. S. Langer, “Towards Accurate Recovery of Shape from Shading Under Diﬀuse Lighting,” *IEEE Trans. on Pattern Analysis and Machine Intelligence*, vol. 19, no. 9, pp. 1020–1025, Sept. 1997. Cited on p. 450

[[1700](#_bookmark0)] Stewart, Jason, and Gareth Thomas, “Tiled Rendering Showdown: Forward++ vs. Deferred Rendering,” *Game Developers Conference*, Mar. 2013. Cited on p. 896, 897, 914

[[1701](#_bookmark0)] Stewart, Jason, “Compute-Based Tiled Culling,” in Wolfgang Engel, ed., *GPU Pro*6, CRC Press, pp. 435–458, 2015. Cited on p. 894, 896, 914

[[1702](#_bookmark0)] Stich, Martin, Carsten W¨achter, and Alexander Keller, “Eﬃcient and Robust Shadow Volumes Using Hierarchical Occlusion Culling and Geometry Shaders,” in Hubert Nguyen, ed., *GPU Gems 3*, Addison-Wesley, pp. 239–256, 2007. Cited on p. 233

[[1703](#_bookmark0)] Stiles, W. S., and J. M. Burch, “Interim Report to the Commission Internationale de l’E´clairage Zurich, 1955, on the National Physical Laboratory’s Investigation of Colour-

Matching (1955),” *Optica Acta*, vol. 2, no. 4, pp. 168–181, 1955. Cited on p. 273

[[1704](#_bookmark0)] Stokes, Michael, Matthew Anderson, Srinivasan Chandrasekar, and Ricardo Motta, “A Stan- dard Default Color Space for the Internet—sRGB,” Version 1.10, *International Color Con- sortium*, Nov. 1996. Cited on p. 278

[[1705](#_bookmark0)] Stone, Jonathan, “Radially-Symmetric Reﬂection Maps,” in *SIGGRAPH 2009 Talks*, ACM, article no. 24, Aug. 2009. Cited on p. 414

[[1706](#_bookmark0)] Stone, Maureen, *A Field Guide to Digital Color*, A K Peters, Ltd., Aug. 2003. Cited on p. 276

[[1707](#_bookmark0)] Stone, Maureen, “Representing Colors as Three Numbers,” *IEEE Computer Graphics and Applications*, vol. 25, no. 4, pp. 78–85, July/Aug. 2005. Cited on p. 272, 276

[[1708](#_bookmark0)] Storsj¨o, Martin, *Efficient Triangle Reordering for Improved Vertex Cache Utilisation in Real- time Rendering*, MSc thesis, Department of Information Technologies, Faculty of Technology,

˚Abo Akademi University, 2008. Cited on p. 701

[[1709](#_bookmark0)] Story, Jon, and Holger Gruen, “High Quality Direct3D 10.0 & 10.1 Accelerated Techniques,”

*Game Developers Conference*, Mar. 2009. Cited on p. 249

[[1710](#_bookmark0)] Story, Jon, “DirectCompute Accelerated Separable Filtering,” *Game Developers Conference*,

Mar. 2011. Cited on p. 54, 518

[[1711](#_bookmark0)] Story, Jon, “Advanced Geometrically Correct Shadows for Modern Game Engines,” *Game Developers Conference*, Mar. 2016. Cited on p. 224, 261, 262

[[1712](#_bookmark0)] Story, Jon, and Chris Wyman, “HFTS: Hybrid Frustum-Traced Shadows in *The Division*,” in *ACM SIGGRAPH 2016 Talks*, ACM, article no. 13, July 2016. Cited on p. 261

[[1713](#_bookmark0)] Strauss, Paul S., “A Realistic Lighting Model for Computer Animators,” *IEEE Computer Graphics and Applications*, vol. 10, no. 6, pp. 56–64, Nov. 1990. Cited on p. 324

[[1714](#_bookmark0)] Str¨om, Jacob, and Tomas Akenine-M¨oller, “iPACKMAN: High-Quality, Low-Complexity Tex- ture Compression for Mobile Phones,” in *Graphics Hardware 2006*, Eurographics Association, pp. 63–70, July 2005. Cited on p. 194

[[1715](#_bookmark0)] Str¨om, Jacob, and Martin Pettersson, “ETC2: Texture Compression Using Invalid Combina- tions,” in *Graphics Hardware 2007*, Eurographics Association, pp. 49–54, Aug. 2007. Cited on p. 194

[[1716](#_bookmark0)] Str¨om, J., P. Wennersten, J. Rasmusson, J. Hasselgren, J. Munkberg, P. Clarberg, and T. Akenine-Mo¨ller, “Floating-Point Buﬀer Compression in a Uniﬁed Codec Architecture,” in *Graphics Hardware 2008*, Eurographics Association, pp. 75–84, June 2008. Cited on p. 1009,

1018, 1038

[[1717](#_bookmark0)] Str¨om, Jacob, and Per Wennersten, “Lossless Compression of Already Compressed Textures,” in *Proceedings of the ACM SIGGRAPH/EUROGRAPHICS Conference on High-Performance Graphics*, ACM, pp. 177–182, Aug. 2011. Cited on p. 870

[[1718](#_bookmark0)] Str¨om, J., K. ˚Astr¨om, and T. Akenine-M¨oller, “Immersive Linear Algebra,” http:// immersivemath.com, 2015. Cited on p. 102, 1047

[[1719](#_bookmark0)] Strothotte, Thomas, and Stefan Schlechtweg, *Non-Photorealistic Computer Graphics: Mod- eling, Rendering, and Animation*, Morgan Kaufmann, 2002. Cited on p. 652, 678

[[1720](#_bookmark0)] Strugar, F., “Continuous Distance-Dependent Level of Detail for Rendering Heightmaps,” *Journal of Graphics, GPU, and Game Tools*, vol. 14, no. 4, pp. 57–74, 2009. Cited on p. 876, 877

[[1721](#_bookmark0)] Sugden, B., and M. Iwanicki, “Mega Meshes: Modelling, Rendering and Lighting a World Made of 100 Billion Polygons,” *Game Developers Conference*, Mar. 2011. Cited on p. 483, 868, 870

[[1722](#_bookmark0)] Sun, Bo, Ravi Ramamoorthi, Srinivasa Narasimhan, and Shree Nayar, “A Practical Analytic Single Scattering Model for Real Time Rendering,” *ACM Transactions on Graphics (SIG-*

*GRAPH 2005)*, vol. 24, no. 3, pp. 1040–1049, 2005. Cited on p. 604

[[1723](#_bookmark0)] Sun, Xin, Qiming Hou, Zhong Ren, Kun Zhou, and Baining Guo, “Radiance Transfer Biclus- tering for Real-Time All-Frequency Biscale Rendering,” *IEEE Transactions on Visualization and Computer Graphics*, vol. 17, no. 1, pp. 64–73, 2011. Cited on p. 402

[[1724](#_bookmark0)] Sutherland, Ivan E., Robert F. Sproull, and Robert F. Schumacker, “A Characterization of Ten Hidden-Surface Algorithms,” *Computing Surveys*, vol. 6, no. 1, pp. 1–55, Mar. 1974.

Cited on p. 1048

[[1725](#_bookmark0)] Sutter, Herb, “The Free Lunch Is Over,” *Dr. Dobb’s Journal*, vol. 30, no. 3, Mar. 2005. Cited on p. 806, 815

[[1726](#_bookmark0)] Svarovsky, Jan, “View-Independent Progressive Meshing,” in Mark DeLoura, ed., *Game Pro- gramming Gems*, Charles River Media, pp. 454–464, 2000. Cited on p. 707, 711

[[1727](#_bookmark0)] Swoboda, Matt, “Deferred Lighting and Post Processing on PLAYSTATION 3,” *Game De- velopers Conference*, Mar. 2009. Cited on p. 893

[[1728](#_bookmark0)] Swoboda, Matt, “Ambient Occlusion in Frameranger,” *direct to video blog*, Jan. 15, 2010.

Cited on p. 453

[[1729](#_bookmark0)] Szeliski, Richard, *Computer Vision: Algorithms and Applications*, Springer, 2011. Cited on p. 130, 200, 543, 549, 587, 661, 1048

[[1730](#_bookmark0)] Szirmay-Kalos, L´aszl´o, Barnaba´s Aszo´di, Istva´n Laz´anyi, and M´aty´as Premecz, “Approximate Ray-Tracing on the GPU with Distance Impostors,” *Computer Graphics Forum*, vol. 24, no. 3, pp. 695–704, 2005. Cited on p. 502

[[1731](#_bookmark0)] Szirmay-Kalos, La´szl´o, and Tama´s Umenhoﬀer, “Displacement Mapping on the GPU—State of the Art,” *Computer Graphics Forum*, vol. 27, no. 6, pp. 1567–1592, 2008. Cited on p. 222, 933

[[1732](#_bookmark0)] Szirmay-Kalos, La´szl´o, Tama´s Umenhoﬀer, Gustavo Patow, L´aszl´o Sz´ecsi, and Mateu Sbert, “Specular Eﬀects on the GPU: State of the Art,” *Computer Graphics Forum*, vol. 28, no. 6, pp. 1586–1617, 2009. Cited on p. 435

[[1733](#_bookmark0)] Szirmay-Kalos, L´aszl´o, Tama´s Umenhoﬀer, Bal´azs T´oth, L´aszl´o Sz´ecsi, and Mateu Sbert, “Vol- umetric Ambient Occlusion for Real-Time Rendering and Games,” *IEEE Computer Graphics and Applications*, vol. 30, no. 1, pp. 70–79, 2010. Cited on p. 459

[[1734](#_bookmark0)] Tabellion, Eric, and Arnauld Lamorlette, “An Approximate Global Illumination System for Computer Generated Films,” *ACM Transactions on Graphics (SIGGRAPH 2004)*, vol. 23, no. 3, pp. 469–476, Aug. 2004. Cited on p. 26, 491

[[1735](#_bookmark0)] Tadamura, Katsumi, Xueying Qin, Guofang Jiao, and Eihachiro Nakamae, “Rendering Opti- mal Solar Shadows Using Plural Sunlight Depth Buﬀers,” in *Computer Graphics International 1999*, IEEE Computer Society, pp. 166–173, June 1999. Cited on p. 242

[[1736](#_bookmark0)] Takayama, Kenshi, Alec Jacobson, Ladislav Kavan, and Olga Sorkine-Hornung, “A Simple Method for Correcting Facet Orientations in Polygon Meshes Based on Ray Casting,” *Journal of Computer Graphics Techniques*, vol. 3, no. 4, pp. 53–63, 2014. Cited on p. 693

[[1737](#_bookmark0)] Takeshige, Masaya, “The Basics of GPU Voxelization,” *NVIDIA GameWorks* blog, Mar. 22, 2015. Cited on p. 582

[[1738](#_bookmark0)] Tampieri, Filippo, “Newell’s Method for the Plane Equation of a Polygon,” in David Kirk, ed., *Graphics Gems III*, Academic Press, pp. 231–232, 1992. Cited on p. 685

[[1739](#_bookmark0)] Tanner, Christopher C., Christopher J. Migdal, and Michael T. Jones, “The Clipmap: A Vir- tual Mipmap,” in *SIGGRAPH ’98: Proceedings of the 25th Annual Conference on Computer Graphics and Interactive Techniques*, ACM, pp. 151–158, July 1998. Cited on p. 570, 867, 872

[[1740](#_bookmark0)] Tarini, Marco, Kai Hormann, Paolo Cignoni, and Claudio Montani, “PolyCube-Maps,” *ACM Transactions on Graphics (SIGGRAPH 2004)*, vol. 23, no. 3, pp. 853–860, Aug. 2004. Cited

on p. 171

[[1741](#_bookmark0)] Tatarchuk, Natalya, “Artist-Directable Real-Time Rain Rendering in City Environments,”

*SIGGRAPH Advanced Real-Time Rendering in 3D Graphics and Games course*, Aug. 2006.

Cited on p. 604

[[1742](#_bookmark0)] Tatarchuk, Natalya, “Dynamic Parallax Occlusion Mapping with Approximate Soft Shadows,”

*SIGGRAPH Advanced Real-Time Rendering in 3D Graphics and Games course*, Aug. 2006.

Cited on p. 217, 218, 222

[[1743](#_bookmark0)] Tatarchuk, Natalya, “Practical Parallax Occlusion Mapping with Approximate Soft Shadows for Detailed Surface Rendering,” *SIGGRAPH Advanced Real-Time Rendering in 3D Graphics and Games course*, Aug. 2006. Cited on p. 217, 218, 222

[[1744](#_bookmark0)] Tatarchuk, Natalya, and Jeremy Shopf, “Real-Time Medical Visualization with FireGL,” *SIG-*

*GRAPH AMD Technical Talk*, Aug. 2007. Cited on p. 607, 753

[[1745](#_bookmark0)] Tatarchuk, Natalya, “Real-Time Tessellation on GPU,” *SIGGRAPH Advanced Real-Time Rendering in 3D Graphics and Games course*, Aug. 2007. Cited on p. 770

[[1746](#_bookmark0)] Tatarchuk, Natalya, Christopher Oat, Jason L. Mitchell, Chris Green, Johan Andersson, Mar- tin Mittring, Shanon Drone, and Nico Galoppo, *SIGGRAPH Advanced Real-Time Rendering in 3D Graphics and Games course*, Aug. 2007. Cited on p. 1115

[[1747](#_bookmark0)] Tatarchuk, Natalya, Chris Tchou, and Joe Venzon, “*Destiny*: From Mythic Science Fiction to Rendering in Real-Time,” *SIGGRAPH Advances in Real-Time Rendering in Games course*,

July 2013. Cited on p. 568, 569, 892

[[1748](#_bookmark0)] Tatarchuk, Natalya, and Shi Kai Wang, “Creating Content to Drive *Destiny*’s Investment Game: One Solution to Rule Them All,” *SIGGRAPH Production Session*, Aug. 2014. Cited on p. 366

[[1749](#_bookmark0)] Tatarchuk, Natalya, “Destiny’s Multithreaded Rendering Architecture,” *Game Developers Conference*, Mar. 2015. Cited on p. 815

[[1750](#_bookmark0)] Tatarchuk, Natalya, and Chris Tchou, “*Destiny* Shader Pipeline,” *Game Developers Confer- ence*, Feb.–Mar. 2017. Cited on p. 128, 129, 815

[[1751](#_bookmark0)] Taubin, Gabriel, Andr´e Gu´eziec, William Horn, and Francis Lazarus, “Progressive Forest Split Compression,” in *SIGGRAPH ’98: Proceedings of the 25th Annual Conference on Computer Graphics and Interactive Techniques*, ACM, pp. 123–132, July 1998. Cited on p. 706

[[1752](#_bookmark0)] Taylor, Philip, “Per-Pixel Lighting,” *Driving DirectX* web column, Nov. 13, 2001. Cited on p. 432

[[1753](#_bookmark0)] Tector, C., “Streaming Massive Environments from Zero to 200MPH,” *Game Developers Conference*, Mar. 2010. Cited on p. 871

[[1754](#_bookmark0)] Teixeira, Diogo, “Baking Normal Maps on the GPU,” in Hubert Nguyen, ed., *GPU Gems 3*,

Addison-Wesley, pp. 491–512, 2007. Cited on p. 853

[[1755](#_bookmark0)] Teller, Seth J., and Carlo H. S´equin, “Visibility Preprocessing for Interactive Walkthroughs,”

*Computer Graphics (SIGGRAPH ’91 Proceedings)*, vol. 25, no. 4, pp. 61–69, July 1991. Cited

on p. 837

[[1756](#_bookmark0)] Teller, Seth J., *Visibility Computations in Densely Occluded Polyhedral Environments*, PhD thesis, Department of Computer Science, University of Berkeley, 1992. Cited on p. 837

[[1757](#_bookmark0)] Teller, Seth, and Pat Hanrahan, “Global Visibility Algorithms for Illumination Computa- tions,” in *SIGGRAPH ’94: Proceedings of the 21st Annual Conference on Computer Graphics and Interactive Techniques*, ACM, pp. 443–450, July 1994. Cited on p. 837

[[1758](#_bookmark0)] Teschner, Matthias, “Advanced Computer Graphics: Sampling,” Course Notes, Computer Science Department, University of Freiburg, 2016. Cited on p. 144, 165

[[1759](#_bookmark0)] Tessman, Thant, “Casting Shadows on Flat Surfaces,” *Iris Universe*, pp. 16–19, Winter 1989.

Cited on p. 225

[[1760](#_bookmark0)] Tevs, A., I. Ihrke, and H.-P. Seidel, “Maximum Mipmaps for Fast, Accurate, and Scalable Dynamic Height Field Rendering,” in *Proceedings of the 2008 Symposium on Interactive 3D Graphics and Games*, ACM, pp. 183–190, 2008. Cited on p. 220

[[1761](#_bookmark0)] Thibault, Aaron P., and Sean “Zoner” Cavanaugh, “Making Concept Art Real for Border- lands,” *SIGGRAPH Stylized Rendering in Games course*, July 2010. Cited on p. 652, 661, 662, 664, 678

[[1762](#_bookmark0)] Thibieroz, Nicolas, “Deferred Shading with Multiple Render Targets,” in Wolfgang Engel, ed., *ShaderX*2*: Introductions & Tutorials with DirectX 9*, Wordware, pp. 251–269, 2004. Cited on p. 882, 884

[[1763](#_bookmark0)] Thibieroz, Nicolas, “Robust Order-Independent Transparency via Reverse Depth Peeling in DirectX 10,” in Wolfgang Engel, ed., *ShaderX*6, Charles River Media, pp. 211–226, 2008.

Cited on p. 154

[[1764](#_bookmark0)] Thibieroz, Nicolas, “Deferred Shading with Multisampling Anti-Aliasing in DirectX 10,” in Wolfgang Engel, ed., *ShaderX*7, Charles River Media, pp. 225–242, 2009. Cited on p. 888

[[1765](#_bookmark0)] Thibieroz, Nicolas, “Order-Independent Transparency Using Per-Pixel Linked Lists,” in Wolf- gang Engel, ed., *GPU Pro*2, A K Peters/CRC Press, pp. 409–431, 2011. Cited on p. 155

[[1766](#_bookmark0)] Thibieroz, Nicolas, “Deferred Shading Optimizations,” *Game Developers Conference*, Mar.

2011. Cited on p. 886, 887, 892, 900

[[1767](#_bookmark0)] Thomas, Gareth, “Compute-Based GPU Particle Systems,” *Game Developers Conference*,

Mar. 2014. Cited on p. 572

[[1768](#_bookmark0)] Thomas, Gareth, “Advancements in Tiled-Based Compute Rendering,” *Game Developers Conference*, Mar. 2015. Cited on p. 803, 894, 896, 900, 901

[[1769](#_bookmark0)] Thomas, Spencer W., “Decomposing a Matrix into Simple Transformations,” in James Arvo, ed., *Graphics Gems II*, Academic Press, pp. 320–323, 1991. Cited on p. 72, 74

[[1770](#_bookmark0)] Thu¨rmer, Grit, and Charles A. Wu¨thrich, “Computing Vertex Normals from Polygonal Facets,” *journal of graphics tools*, vol. 3, no. 1, pp. 43–46, 1998. Also collected in [112].

Cited on p. 695

[[1771](#_bookmark0)] Timonen, Ville, “Line-Sweep Ambient Obscurance,” *Eurographics Symposium on Rendering*,

June 2013. Cited on p. 461

[[1772](#_bookmark0)] Toisoul, Antoine, and Abhijeet Ghosh, “Practical Acquisition and Rendering of Diﬀraction Eﬀects in Surface Reﬂectance,” *ACM Transactions on Graphics*, vol. 36, no. 5, pp. 166:1– 166:16, Oct. 2017. Cited on p. 361

[[1773](#_bookmark0)] Toisoul, Antoine, and Abhijeet Ghosh, “Real-Time Rendering of Realistic Surface Diﬀraction with Low Rank Factorisation,” *European Conference on Visual Media Production (CVMP)*,

Dec. 2017. Cited on p. 361

[[1774](#_bookmark0)] Toksvig, Michael, “Mipmapping Normal Maps,” *journal of graphics tools*, vol. 10, no. 3, pp. 65–71, 2005. Cited on p. 369

[[1775](#_bookmark0)] Tokuyoshi, Yusuke, “Error Reduction and Simpliﬁcation for Shading Anti-Aliasing,” Technical Report, Square Enix, Apr. 2017. Cited on p. 371

[[1776](#_bookmark0)] Torborg, J., and J. T. Kajiya, “Talisman: Commodity Realtime 3D Graphics for the PC,” in *SIGGRAPH ’96: Proceedings of the 23rd Annual Conference on Computer Graphics and Interactive Techniques*, ACM, pp. 353–363, Aug. 1996. Cited on p. 551

[[1777](#_bookmark0)] Torchelsen, Rafael P., Joa˜o L. D. Comba, and Rui Bastos, “Practical Geometry Clipmaps for Rendering Terrains in Computer Games,” in Wolfgang Engel, ed., *ShaderX*6, Charles River Media, pp. 103–114, 2008. Cited on p. 612, 873

[[1778](#_bookmark0)] T¨oro¨k, Bala´zs, and Tim Green, “The Rendering Features of *The Witcher 3: Wild Hunt*,” in

*ACM SIGGRAPH 2015 Talks*, ACM, article no. 7, Aug. 2015. Cited on p. 366, 420, 889

[[1779](#_bookmark0)] Torrance, K., and E. Sparrow, “Theory for Oﬀ-Specular Reﬂection from Roughened Surfaces,” *Journal of the Optical Society of America*, vol. 57, no. 9, pp. 1105–1114, Sept. 1967. Cited on p. 314, 334

[[1780](#_bookmark0)] Toth, Robert, “Avoiding Texture Seams by Discarding Filter Taps,” *Journal of Computer Graphics Techniques*, vol. 2, no. 2, pp. 91–104, 2013. Cited on p. 191

[[1781](#_bookmark0)] Toth, Robert, Jon Hasselgren, and Tomas Akenine-Mo¨ller, “Perception of Highlight Disparity at a Distance in Consumer Head-Mounted Displays,” in *Proceedings of the 7th Conference on High-Performance Graphics*, ACM, pp. 61–66, Aug. 2015. Cited on p. 934

[[1782](#_bookmark0)] Toth, Robert, Jim Nilsson, and Tomas Akenine-M¨oller, “Comparison of Projection Methods for Rendering Virtual Reality,” in *High-Performance Graphics 2016*, Eurographics Associa- tion, pp. 163–171, June 2016. Cited on p. 930

[[1783](#_bookmark0)] Tran, Ray, “Facetted Shadow Mapping for Large Dynamic Game Environments,” in Wolfgang Engel, ed., *ShaderX*7, Charles River Media, pp. 363–371, 2009. Cited on p. 244

[[1784](#_bookmark0)] Trapp, Matthias, and Ju¨rgen D¨ollner, “Automated Combination of Real-Time Shader Pro- grams,” in *Eurographics 2007—Short Papers*, Eurographics Association, pp. 53–56, Sept. 2007. Cited on p. 128

[[1785](#_bookmark0)] Trebilco, Damian, “Light-Indexed Deferred Rendering,” in Wolfgang Engel, ed., *ShaderX*7,

Charles River Media, pp. 243–258, 2009. Cited on p. 893

[[1786](#_bookmark0)] Treglia, Dante, ed., *Game Programming Gems 3*, Charles River Media, 2002. Cited on p. 1089

[[1787](#_bookmark0)] Trop, Oren, Ayellet Tal, and Ilan Shimshoni, “A Fast Triangle to Triangle Intersection Test for Collision Detection,” *Computer Animation & Virtual Worlds*, vol. 17, no. 5, pp. 527–535, 2006. Cited on p. 974

[[1788](#_bookmark0)] Trowbridge, T. S., and K. P. Reitz, “Average Irregularity Representation of a Roughened Surface for Ray Reﬂection,” *Journal of the Optical Society of America*, vol. 65, no. 5, pp. 531– 536, May 1975. Cited on p. 340

[[1789](#_bookmark0)] Trudel, N., “Improving Geometry Culling for *Deus Ex: Mankind Divided*,” *Game Developers Conference*, Mar. 2016. Cited on p. 850

[[1790](#_bookmark0)] Tuft, David, “Plane-Based Depth Bias for Percentage Closer Filtering,” *Game Developer*, vol. 17, no. 5, pp. 35–38, May 2010. Cited on p. 249, 250

[[1791](#_bookmark0)] Tuft, David, “Cascaded Shadow Maps,” *Windows Dev Center: DirectX Graphics and Gaming Technical Articles*, 2011. Cited on p. 244, 245, 247, 265

[[1792](#_bookmark0)] Tuft, David, “Common Techniques to Improve Shadow Depth Maps,” *Windows Dev Center:*

*DirectX Graphics and Gaming Technical Articles*, 2011. Cited on p. 236, 239, 240, 265

[[1793](#_bookmark0)] Turkowski, Ken, “Filters for Common Resampling Tasks,” in Andrew S. Glassner, ed., *Graph- ics Gems*, Academic Press, pp. 147–165, 1990. Cited on p. 136

[[1794](#_bookmark0)] Turkowski, Ken, “Properties of Surface-Normal Transformations,” in Andrew S. Glassner, ed.,

*Graphics Gems*, Academic Press, pp. 539–547, 1990. Cited on p. 68

[[1795](#_bookmark0)] Turkowski, Ken, “Incremental Computation of the Gaussian,” in Hubert Nguyen, ed., *GPU Gems 3*, Addison-Wesley, pp. 877–890, 2007. Cited on p. 515

[[1796](#_bookmark0)] Ulrich, Thatcher, “Loose Octrees,” in Mark DeLoura, ed., *Game Programming Gems*, Charles River Media, pp. 444–453, 2000. Cited on p. 826

[[1797](#_bookmark0)] Ulrich, Thatcher, “Rendering Massive Terrains Using Chunked Level of Detail Control,” *SIG- GRAPH Super-Size It! Scaling up to Massive Virtual Worlds course*, July 2002. Cited on p. 874, 875

[[1798](#_bookmark0)] Uludag, Yasin, “Hi-Z Screen-Space Tracing,” in Wolfgang Engel, ed., *GPU Pro*5, CRC Press, pp. 149–192, 2014. Cited on p. 507

[[1799](#_bookmark0)] Umenhoﬀer, Tam´as, L´azlo´ Szirmay-Kalos, and G´abor Szija´rt´o, “Spherical Billboards and Their Application to Rendering Explosions,” in *Graphics Interface 2006*, Canadian Human-

Computer Communications Society, pp. 57–63, 2006. Cited on p. 559

[[1800](#_bookmark0)] Umenhoﬀer, Tam´as, L´aszl´o Szirmay-Kalos, and Ga´bor Sz´ıj´art´o, “Spherical Billboards for Ren- dering Volumetric Data,” in Wolfgang Engel, ed., *ShaderX*5, Charles River Media, pp. 275– 285, 2006. Cited on p. 559

[[1801](#_bookmark0)] *Unity User Manual*, Unity Technologies, 2017. Cited on p. 287

[[1802](#_bookmark0)] *Unreal Engine 4 Documentation*, Epic Games, 2017. Cited on p. 114, 126, 128, 129, 262, 287,

364, 611, 644, 920, 923, 932, 934, 939

[[1803](#_bookmark0)] Upchurch, Paul, and Mathieu Desbrun, “Tightening the Precision of Perspective Rendering,”

*journal of graphics tools*, vol. 16, no. 1, pp. 40–56, 2012. Cited on p. 101

[[1804](#_bookmark0)] Upstill, S., *The RenderMan Companion: A Programmer’s Guide to Realistic Computer Graphics*, Addison-Wesley, 1990. Cited on p. 37

[[1805](#_bookmark0)] Vaidyanathan, K., M. Salvi, R. Toth, T. Foley, T. Akenine-M¨oller, J. Nilsson, J. Munkberg,

J. Hasselgren, M. Sugihara, P. Clarberg, T. Janczak, and A. Lefohn, “Coarse Pixel Shading,” in *High Performance Graphics 2014*, Eurographics Association, pp. 9–18, June 2014. Cited on p. 924, 1013

[[1806](#_bookmark0)] Vaidyanathan, Karthik, Jacob Munkberg, Petrik Clarberg, and Marco Salvi, “Layered Light Field Reconstruction for Defocus Blur,” *ACM Transactions on Graphics*, vol. 34, no. 2, pp. 23:1–23:12, Feb. 2015. Cited on p. 536

[[1807](#_bookmark0)] Vaidyanathan, K. T. Akenine-M¨oller, and M. Salvi, “Watertight Ray Traversal with Reduced Precision,” in *High-Performance Graphics 2016*, Eurographics Association, pp. 33–40, June 2016. Cited on p. 1039

[[1808](#_bookmark0)] Vainio, Matt, “The Visual Eﬀects of *inFAMOUS: Second Son*,” *Game Developers Conference*,

Mar. 2014. Cited on p. 572

[[1809](#_bookmark0)] Valient, Michal, “Deferred Rendering in *Killzone 2*,” *Develop Conference*, July 2007. Cited on p. 882, 885, 886, 887

[[1810](#_bookmark0)] Valient, Michal, “Stable Rendering of Cascaded Shadow Maps,” in Wolfgang Engel, ed.,

*ShaderX*6, Charles River Media, pp. 231–238, 2008. Cited on p. 239, 245, 247

[[1811](#_bookmark0)] Valient, Michal, “Shadows + Games: Practical Considerations,” *SIGGRAPH Efficient Real-*

*Time Shadows course*, Aug. 2012. Cited on p. 245, 246, 252

[[1812](#_bookmark0)] Valient, Michal, “Taking *Killzone: Shadow Fall* Image Quality into the Next Generation,”

*Game Developers Conference*, Mar. 2014. Cited on p. 148, 235, 245, 490, 506, 507, 509, 523,

608, 609

[[1813](#_bookmark0)] Van Verth, Jim, “Doing Math with RGB (and A),” *Game Developers Conference*, Mar. 2015.

Cited on p. 151, 208

[[1814](#_bookmark0)] Vaxman, Amir, Marcel Campen, Olga Diamanti, Daniele Panozzo, David Bommes, Klaus Hildebrandt, and Mirela Ben-Chen, “Directional Field Synthesis, Design, and Processing,”

*Computer Graphics Forum*, vol. 35, no. 2, pp. 545–572, 2016. Cited on p. 672

[[1815](#_bookmark0)] Veach, Eric, “Robust Monte Carlo Methods for Light Transport Simulation,” PhD Disserta- tion, Stanford University, Dec. 1997. Cited on p. 445

[[1816](#_bookmark0)] Venkataraman, S., “Fermi Asynchronous Texture Transfers,” in Patrick Cozzi & Christophe Riccio, eds., *OpenGL Insights*, CRC Press, pp. 415–430, 2012. Cited on p. 1034

[[1817](#_bookmark0)] Villanueva, Alberto Jaspe, Fabio Marton, and Enrico Gobbetti, “SSVDAGs: Symmetry- Aware Sparse Voxel DAGs,” in *Proceedings of the 20th ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games*, ACM, pp. 7–14, 2016. Cited on p. 586

[[1818](#_bookmark0)] *Virtual Terrain Project*,[http://www.vterrain.org](http://www.vterrain.org/). Cited on p. 877

[[1819](#_bookmark0)] Vlachos, Alex, J¨org Peters, Chas Boyd, and Jason L. Mitchell, “Curved PN Triangles,” in

*Proceedings of the 2001 Symposium on Interactive 3D Graphics*, ACM, pp. 159–166, 2001.

Cited on p. 744, 745, 746

[[1820](#_bookmark0)] Vlachos, Alex, and John Isidoro, “Smooth C2 Quaternion-Based Flythrough Paths,” in Mark DeLoura, ed., *Game Programming Gems 2*, Charles River Media, pp. 220–227, 2001. Cited on p. 102

[[1821](#_bookmark0)] Vlachos, Alex, “Post Processing in *The Orange Box*,” *Game Developers Conference*, Feb.

2008. Cited on p. 288, 538

[[1822](#_bookmark0)] Vlachos, Alex, “Rendering Wounds in *Left 4 Dead 2*,” *Game Developers Conference*, Mar.

2010. Cited on p. 366

[[1823](#_bookmark0)] Vlachos, Alex, “Advanced VR Rendering,” *Game Developers Conference*, Mar. 2015. Cited on p. 371, 628, 922, 925, 926, 927, 933, 934, 939, 940, 1010

[[1824](#_bookmark0)] Vlachos, Alex, “Advanced VR Rendering Performance,” *Game Developers Conference*, Mar.

2016. Cited on p. 784, 805, 928, 930, 931, 936, 937, 938, 940

[[1825](#_bookmark0)] Voorhies, Douglas, “Space-Filling Curves and a Measure of Coherence,” in James Arvo, ed.,

*Graphics Gems II*, Academic Press, pp. 26–30, 1991. Cited on p. 1018

[[1826](#_bookmark0)] *Vulkan Overview*, Khronos Group, Feb. 2016. Cited on p. 806

[[1827](#_bookmark0)] Walbourn, Chuck, ed., *SIGGRAPH Introduction to Direct3D 10 course*, Aug. 2007. Cited on p. 798

[[1828](#_bookmark0)] Wald, Ingo, William R. Mark, Johannes Gu¨nther, Solomon Boulos, Thiago Ize, Warren Hunt, Steven G. Parker, and Peter Shirley, “State of the Art in Ray Tracing Animated Scenes,”

*Computer Graphics Forum*, vol. 28, no. 6, pp. 1691–1722, 2009. Cited on p. 953

[[1829](#_bookmark0)] Wald, Ingo, Sven Woop, Carsten Benthin, Gregory S. Johnsson, and Manfred Ernst, “Embree: A Kernel Framework for Eﬃcient CPU Ray Tracing,” *ACM Transactions on Graphics*, vol. 33, no. 4, pp. 143:1–143:8, 2014. Cited on p. 452, 821

[[1830](#_bookmark0)] Walker, R., and J. Snoeyink, “Using CSG Representations of Polygons for Practical Point-in- Polygon Tests,” in *ACM SIGGRAPH ’97 Visual Proceedings*, ACM, p. 152, Aug. 1997. Cited on p. 967

[[1831](#_bookmark0)] Wallace, Evan, “Rendering Realtime Caustics in WebGL,” *Medium* blog, Jan. 7, 2016. Cited on p. 631

[[1832](#_bookmark0)] Walter, Bruce, Sebastian Fernandez, Adam Arbree, Kavita Bala, Michael Donikian, and Don- ald P. Greenberg, “Lightcuts: A Scalable Approach to Illumination,” *ACM Transactions on Graphics*, vol. 24, no. 3, pp. 1098–1107, 2005. Cited on p. 431, 901

[[1833](#_bookmark0)] Walter, Bruce, Stephen R. Marschner, Hongsong Li, and Kenneth E. Torrance, “Microfacet Models for Refraction through Rough Surfaces,” *Rendering Techniques 2007*, Eurographics Association, pp. 195–206, June 2007. Cited on p. 334, 337, 339, 340, 369, 419

[[1834](#_bookmark0)] Walton, Patrick, “Pathﬁnder, a Fast GPU-Based Font Rasterizer in Rust,” *pcwalton blog*, Feb.

14, 2017. Cited on p. 676

[[1835](#_bookmark0)] Wan, Liang, Tien-Tsin Wong, and Chi-Sing Leung, “Isocube: Exploiting the Cubemap Hard- ware,” *IEEE Transactions on Visualization and Computer Graphics*, vol. 13, no. 4, pp. 720– 731, July 2007. Cited on p. 412

[[1836](#_bookmark0)] Wan, Liang, Tien-Tsin Wong, Chi-Sing Leung, and Chi-Wing Fu, “Isocube: A Cubemap with Uniformly Distributed and Equally Important Texels,” in Wolfgang Engel, ed., *ShaderX*6,

Charles River Media, pp. 83–92, 2008. Cited on p. 412

[[1837](#_bookmark0)] Wang, Beibei, and Huw Bowles, “A Robust and Flexible Real-Time Sparkle Eﬀect,” in *Pro- ceedings of the Eurographics Symposium on Rendering: Experimental Ideas & Implementa- tions*, Eurographics Association, pp. 49–54, 2016. Cited on p. 372

[[1838](#_bookmark0)] Wang, Jiaping, Peiran Ren, Minmin Gong, John Snyder, and Baining Guo, “All-Frequency Rendering of Dynamic, Spatially-Varying Reﬂectance,” *ACM Transactions on Graphics*, vol. 28, no. 5, pp. 133:1–133:10, 2009. Cited on p. 397, 398, 466, 472

[[1839](#_bookmark0)] Wang, Niniane, “Realistic and Fast Cloud Rendering,” *journal of graphics tools*, vol. 9, no. 3, pp. 21–40, 2004. Cited on p. 556

[[1840](#_bookmark0)] Wang, Niniane, “Let There Be Clouds!” *Game Developer*, vol. 11, no. 1, pp. 34–39, Jan. 2004.

Cited on p. 556

[[1841](#_bookmark0)] Wang, Rui, Ren Ng, David P. Luebke, and Greg Humphreys, “Eﬃcient Wavelet Rotation for Environment Map Rendering,” in *17th Eurographics Symposium on Rendering*, Eurographics Association, pp. 173–182, 2006. Cited on p. 402

[[1842](#_bookmark0)] Wang, R., X. Yang, Y. Yuan, Yazhen, W. Chen, K. Bala, and H. Bao, “Automatic Shader Simpliﬁcation Using Surface Signal Approximation,” *ACM Transactions on Graphics*, vol. 33, no. 6, pp. 226:1–226:11, 2014. Cited on p. 853

[[1843](#_bookmark0)] Wang, R., B. Yu, K. Marco, T. Hu, D. Gutierrez, and H. Bao, “Real-Time Rendering on a Power Budget,” *ACM Transactions on Graphics*, vol. 335 no. 4, pp. 111:1–111:11, 2016. Cited on p. 866

[[1844](#_bookmark0)] Wang, X., X. Tong, S. Lin, S. Hu, B. Guo, and H.-Y. Shum, “Generalized Displacement Maps,” in *15th Eurographics Symposium on Rendering*, Eurographics Association, pp. 227–233, June 2004. Cited on p. 219

[[1845](#_bookmark0)] Wang, Yulan, and Steven Molnar, “Second-Depth Shadow Mapping,” Technical Report TR94- 019, Department of Computer Science, University of North Carolina at Chapel Hill, 1994.

Cited on p. 238

[[1846](#_bookmark0)] Wanger, Leonard, “The Eﬀect of Shadow Quality on the Perception of Spatial Relationships in Computer Generated Imagery,” in *Proceedings of the 1992 Symposium on Interactive 3D Graphics*, ACM, pp. 39–42, 1992. Cited on p. 225, 611

[[1847](#_bookmark0)] Warren, Joe, and Henrik Weimer, *Subdivision Methods for Geometric Design: A Constructive Approach*, Morgan Kaufmann, 2001. Cited on p. 718, 754, 756, 760, 761, 781

[[1848](#_bookmark0)] Wasson, Ben, “Maxwell’s Dynamic Super Resolution Explored,” *The Tech Report* website,

Sept. 30, 2014. Cited on p. 139

[[1849](#_bookmark0)] Watson, Benjamin, and David Luebke, “The Ultimate Display: Where Will All the Pixels Come From?” *Computer*, vol. 38, no. 8, pp. 54–61, Aug. 2005. Cited on p. 1, 808, 817

[[1850](#_bookmark0)] Watt, Alan, and Fabio Policarpo, *Advanced Game Development with Programmable Graphics Hardware*, A K Peters, Ltd., 2005. Cited on p. 220, 222

[[1851](#_bookmark0)] van Waveren, J. M. P., “Real-Time Texture Streaming & Decompression,” Technical Report,

Id Software, Nov. 2006. Cited on p. 870

[[1852](#_bookmark0)] van Waveren, J. M. P., and Ignacio Castan˜o, “Real-Time YCoCg-DXT Decompression,” Tech- nical Report, Id Software, Sept. 2007. Cited on p. 198

[[1853](#_bookmark0)] van Waveren, J. M. P., and Ignacio Castan˜o, “Real-Time Normal Map DXT Compression,”

Technical Report, Id Software, Feb. 2008. Cited on p. 198

[[1854](#_bookmark0)] van Waveren, J. M. P., “id Tech 5 Challenges,” *SIGGRAPH Beyond Programmable Shading course*, Aug. 2009. Cited on p. 812, 869

[[1855](#_bookmark0)] van Waveren, J. M. P., and E. Hart, “Using Virtual Texturing to Handle Massive Texture Data,” *GPU Technology Conference (GTC)*, Sept. 2010. Cited on p. 868, 870

[[1856](#_bookmark0)] van Waveren, J. M. P., “Software Virtual Textures,” Technical Report, Id Software, Feb. 2012.

Cited on p. 868

[[1857](#_bookmark0)] van Waveren, J. M. P., “The Asynchronous Time Warp for Virtual Reality on Consumer Hardware,” in *Proceedings of the 22nd ACM Conference on Virtual Reality Software and Technology*, ACM, pp. 37–46, Nov. 2016. Cited on p. 936, 937

[[1858](#_bookmark0)] Webb, Matthew, Emil Praun, Adam Finkelstein, and Hugues Hoppe, “Fine Tone Con- trol in Hardware Hatching,” in *Proceedings of the 2nd International Symposium on Non-*

*Photorealistic Animation and Rendering*, ACM, pp. 53–58, June 2002. Cited on p. 671

[[1859](#_bookmark0)] Weber, Marco, and Peter Quayle, “Post-Processing Eﬀects on Mobile Devices,” in Wolfgang Engel, ed., *GPU Pro*2, A K Peters/CRC Press, pp. 291–305, 2011. Cited on p. 527

[[1860](#_bookmark0)] Wei, Li-Yi, “Tile-Based Texture Mapping,” in Matt Pharr, ed., *GPU Gems 2*, Addison-Wesley, pp. 189–199, 2005. Cited on p. 175

[[1861](#_bookmark0)] Wei, Li-Yi, Sylvain Lefebvre, Vivek Kwatra, and Greg Turk, “State of the Art in Example- Based Texture Synthesis,’ in *Eurographics 2009—State of the Art Reports*, Eurographics As- sociation, pp. 93–117, 2009. Cited on p. 200

[[1862](#_bookmark0)] Weidlich, Andrea, and Alexander Wilkie, “Arbitrarily Layered Micro-Facet Surfaces,” in

*GRAPHITE 2007*, ACM, pp. 171–178, 2007. Cited on p. 364

[[1863](#_bookmark0)] Weidlich, Andrea, and Alexander Wilkie, *SIGGRAPH Asia Thinking in Layers: Modeling with Layered Materials course*, Aug. 2011. Cited on p. 364

[[1864](#_bookmark0)] Weier, M., M. Stengel, T. Roth, P. Didyk, E. Eisemann, M. Eisemann, S. Grogorick, A. Hinkenjann, E. Kruijﬀ, M. Magnor, K. Myszkowski, and P. Slusallek, “Perception-Driven Accelerated Rendering,” *Computer Graphics Forum*, vol. 36, no. 2, pp. 611–643, 2017. Cited

on p. 587, 940

[[1865](#_bookmark0)] Weiskopf, D., and T. Ertl, “Shadow Mapping Based on Dual Depth Layers,” *Eurographics 2003 Short Presentation*, Sept. 2003. Cited on p. 238

[[1866](#_bookmark0)] Welsh, Terry, “Parallax Mapping with Oﬀset Limiting: A Per-Pixel Approximation of Uneven Surfaces,” Technical Report, Inﬁscape Corp., Jan. 18, 2004. Also collected in [429]. Cited on p. 215, 216

[[1867](#_bookmark0)] Welzl, Emo, “Smallest Enclosing Disks (Balls and Ellipsoids),” in H. Maurer, ed., *New Results and New Trends in Computer Science*, LNCS 555, Springer, pp. 359–370, 1991. Cited on p. 950

[[1868](#_bookmark0)] Wennersten, Per, and Jacob Str¨om, “Table-Based Alpha Compression,” *Computer Graphics Forum*, vol. 28, no. 2, pp. 687–695, 2009. Cited on p. 194

[[1869](#_bookmark0)] Wenzel, Carsten, “Far Cry and DirectX,” *Game Developers Conference*, Mar. 2005. Cited on p. 528, 799

[[1870](#_bookmark0)] Wenzel, Carsten, “Real-Time Atmospheric Eﬀects in Games,” *SIGGRAPH Advanced Real-*

*Time Rendering in 3D Graphics and Games course*, Aug. 2006. Cited on p. 559

[[1871](#_bookmark0)] Wenzel, Carsten, “Real-Time Atmospheric Eﬀects in Games Revisited,” *Game Developers Conference*, Mar. 2007. Cited on p. 551, 556, 601, 602, 614

[[1872](#_bookmark0)] Weronko, S., and S. Andreason, “Real-Time Transformations in *The Order 1886*,” in *ACM SIGGRAPH 2015 Talks*, ACM, article no. 8, Aug. 2015. Cited on p. 91

[[1873](#_bookmark0)] Westin, Stephen H., Hongsong Li, and Kenneth E. Torrance, “A Field Guide to BRDF Mod- els,” Research Note PCG-04-01, Cornell University Program of Computer Graphics, Jan. 2004. Cited on p. 329

[[1874](#_bookmark0)] Westin, Stephen H., Hongsong Li, and Kenneth E. Torrance, “A Comparison of Four BRDF Models,” Research Note PCG-04-02, Cornell University Program of Computer Graphics, Apr. 2004. Cited on p. 329

[[1875](#_bookmark0)] Wetzstein, Gordon, “Focus Cues and Computational Near-Eye Displays with Focus Cues,” *SIGGRAPH Applications of Visual Perception to Virtual Reality course*, Aug. 2017. Cited on p. 549, 923

[[1876](#_bookmark0)] Whatley, David, “Towards Photorealism in Virtual Botany,” in Matt Pharr, ed., *GPU Gems 2*, Addison-Wesley, pp. 7–45, 2005. Cited on p. 207, 858

[[1877](#_bookmark0)] White, John, and Colin Barr´e-Brisebois, “More Performance! Five Rendering Ideas from *Battlefield 3* and *Need For Speed: The Run*,” *SIGGRAPH Advances in Real-Time Rendering in Games course*, Aug. 2011. Cited on p. 527, 804, 896, 898, 904

[[1878](#_bookmark0)] Whiting, Nick, “Integrating the Oculus Rift into Unreal Engine 4,” *Gamasutra*, June 11, 2013.

Cited on p. 934

[[1879](#_bookmark0)] Whitley, Brandon, “The Destiny Particle Architecture,” *SIGGRAPH Advances in Real-Time Rendering in Games course*, Aug. 2017. Cited on p. 571

[[1880](#_bookmark0)] Whittinghill, David, “Nasum Virtualis: A Simple Technique for Reducing Simulator Sickness in Head Mounted VR,” *Game Developers Conference*, Mar. 2015. Cited on p. 920

[[1881](#_bookmark0)] Widmark, M., “Terrain in *Battlefield 3*: A Modern, Complete and Scalable System,” *Game Developers Conference*, Mar. 2012. Cited on p. 869, 878

[[1882](#_bookmark0)] Wiesendanger, Tobias, “Stingray Renderer Walkthrough,” *Autodesk Stingray* blog, Feb. 1, 2017. Cited on p. 549, 803, 814

[[1883](#_bookmark0)] Wihlidal, Graham, “Optimizing the Graphics Pipeline with Compute,” *Game Developers Conference*, Mar. 2016. Cited on p. 54, 798, 834, 837, 840, 848, 849, 851, 908, 986

[[1884](#_bookmark0)] Wihlidal, Graham, “Optimizing the Graphics Pipeline with Compute,” in Wolfgang Engel, ed., *GPU Zen*, Black Cat Publishing, pp. 277–320, 2017. Cited on p. 54, 702, 784, 798, 812,

834, 837, 840, 848, 850, 851, 908, 986

[[1885](#_bookmark0)] Wihlidal, Graham, “4K Checkerboard in *Battlefield 1* and *Mass Effect Andromeda*,” *Game Developers Conference*, Feb.–Mar. 2017. Cited on p. 143, 805, 906, 1042

[[1886](#_bookmark0)] Wiley, Abe, and Thorsten Scheuermann, “The Art and Technology of Whiteout,” *SIGGRAPH AMD Technical Talk*, Aug. 2007. Cited on p. 427

[[1887](#_bookmark0)] Williams, Amy, Steve Barrus, R. Keith Morley, and Peter Shirley, “An Eﬃcient and Robust Ray-Box Intersection Algorithm,” *journal of graphics tools*, vol. 10, no. 1, pp. 49–54, 2005.

Cited on p. 961

[[1888](#_bookmark0)] Williams, Lance, “Casting Curved Shadows on Curved Surfaces,” *Computer Graphics (SIG-*

*GRAPH ’78 Proceedings)*, vol. 12, no. 3, pp. 270–274, Aug. 1978. Cited on p. 234

[[1889](#_bookmark0)] Williams, Lance, “Pyramidal Parametrics,” *Computer Graphics*, vol. 7, no. 3, pp. 1–11, July 1983. Cited on p. 183, 185, 408

[[1890](#_bookmark0)] Willmott, Andrew, “Rapid Simpliﬁcation of Multi-attribute Meshes,” in *Proceedings of the ACM SIGGRAPH Symposium on High-Performance Graphics*, ACM, pp. 151–158, Aug. 2011. Cited on p. 710

[[1891](#_bookmark0)] Wilson, Timothy, “High Performance Stereo Rendering for VR,” *San Diego Virtual Reality Meetup*, Jan. 20, 2015. Cited on p. 927

[[1892](#_bookmark0)] Wimmer, Michael, Peter Wonka, and Franc¸ois Sillion, “Point-Based Impostors for Real-Time Visualization,” in *Rendering Techniques 2001*, Springer, pp. 163–176, June 2001. Cited on p. 561

[[1893](#_bookmark0)] Wimmer, Michael, Daniel Scherzer, and Werner Purgathofer, “Light Space Perspective Shadow Maps,” in *Proceedings of the Fifteenth Eurographics Conference on Rendering Tech- niques*, Eurographics Association, pp. 143–151, June 2004. Cited on p. 241

[[1894](#_bookmark0)] Wimmer, Michael, and Jiˇr´ı Bittner, “Hardware Occlusion Queries Made Useful,” in Matt Pharr, ed., *GPU Gems 2*, Addison-Wesley, pp. 91–108, 2005. Cited on p. 844

[[1895](#_bookmark0)] Wimmer, Michael, and Daniel Scherzer, “Robust Shadow Mapping with Light-Space Perspec- tive Shadow Maps,” in Wolfgang Engel, ed., *ShaderX*4, Charles River Media, pp. 313–330, 2005. Cited on p. 241

[[1896](#_bookmark0)] Winnem¨oller, Holger, “XDoG: Advanced Image Stylization with eXtended Diﬀerence-of- Gaussians,” in *ACM SIGGRAPH/Eurographics Symposium on Non-Photorealistic Animation and Rendering*, ACM, pp. 147–156, Aug. 2011. Cited on p. 665

[[1897](#_bookmark0)] Wloka, Matthias, “Batch, Batch, Batch: What Does It Really Mean?” *Game Developers Conference*, Mar. 2003. Cited on p. 796

[[1898](#_bookmark0)] Wolﬀ, Lawrence B., “A Diﬀuse Reﬂectance Model for Smooth Dielectric Surfaces,” *Journal of the Optical Society of America*, vol. 11, no. 11, pp. 2956–2968, Nov. 1994. Cited on p. 353

[[1899](#_bookmark0)] Wolﬀ, Lawrence B., Shree K. Nayar, and Michael Oren, “Improved Diﬀuse Reﬂection Models for Computer Vision,” *International Journal of Computer Vision*, vol. 30, no. 1, pp. 55–71, 1998. Cited on p. 354

[[1900](#_bookmark0)] Woo, Andrew, “The Shadow Depth Map Revisited,” in David Kirk, ed., *Graphics Gems III*,

Academic Press, pp. 338–342, 1992. Cited on p. 238

[[1901](#_bookmark0)] Woo, Andrew, Andrew Pearce, and Marc Ouellette, “It’s Really Not a Rendering Bug, You See...,” *IEEE Computer Graphics and Applications*, vol. 16, no. 5, pp. 21–25, Sept. 1996.

Cited on p. 688

[[1902](#_bookmark0)] Woo, Andrew, and Pierre Poulin, *Shadow Algorithms Data Miner*, A K Peters/CRC Press, 2011. Cited on p. 223, 265

[[1903](#_bookmark0)] Woodland, Ryan, “Filling the Gaps—Advanced Animation Using Stitching and Skinning,” in Mark DeLoura, ed., *Game Programming Gems*, Charles River Media, pp. 476–483, 2000.

Cited on p. 84, 85

[[1904](#_bookmark0)] Woodland, Ryan, “Advanced Texturing Using Texture Coordinate Generation,” in Mark De- Loura, ed., *Game Programming Gems*, Charles River Media, pp. 549–554, 2000. Cited on p. 200, 221

[[1905](#_bookmark0)] Woop, Sven, J¨org Schmittler, and Philipp Slusallek, “RPU: A Programmable Ray Processing Unit for Realtime Ray Tracing,” *ACM Transactions on Graphics*, vol. 24, no. 3, pp. 434–444,

Aug. 2005. Cited on p. 1039

[[1906](#_bookmark0)] Woop, Sven, Carsten Benthin, and Ingo Wald, “Watertight Ray/Triangle Intersection,” *Jour- nal of Computer Graphics Techniques*, vol. 2, no. 1, pp. 65–82, June 2013. Cited on p. 962

[[1907](#_bookmark0)] Worley, Steven, “A Cellular Texture Basis Function,” in *SIGGRAPH ’96: Proceedings of the 23rd Annual Conference on Computer Graphics and Interactive Techniques*, ACM, pp. 291– 294, 1996. Cited on p. 620

[[1908](#_bookmark0)] Wrenninge, Magnus, *Production Volume Rendering: Design and Implementation*, A K Peter- s/CRC Press, Sept. 2012. Cited on p. 582, 594, 610

[[1909](#_bookmark0)] Wrenninge, Magnus, Chris Kulla, and Viktor Lundqvist, “Oz: The Great and Volumetric,” in *ACM SIGGRAPH 2013 Talks*, ACM, article no. 46, July 2013. Cited on p. 621

[[1910](#_bookmark0)] Wright, Daniel, “Dynamic Occlusion with Signed Distance Fields,” *SIGGRAPH Advances in Real-Time Rendering in Games course*, Aug. 2015. Cited on p. 454, 467

[[1911](#_bookmark0)] Wronski, Bartlomiej, “*Assassin’s Creed: Black Flag*—Road to Next-Gen Graphics,” *Game Developers Conference*, Mar. 2014. Cited on p. 32, 218, 478, 571, 572, 801

[[1912](#_bookmark0)] Wronski, Bartlomiej, “Temporal Supersampling and Antialiasing,” *Bart Wronski* blog, Mar.

15, 2014. Cited on p. 143, 540

[[1913](#_bookmark0)] Wronski, Bartlomiej, “GDC Follow-Up: Screenspace Reﬂections Filtering and Up-Sampling,”

*Bart Wronski* blog, Mar. 23, 2014. Cited on p. 509

[[1914](#_bookmark0)] Wronski, Bartlomiej, “GCN—Two Ways of Latency Hiding and Wave Occupancy,” *Bart Wronski* blog, Mar. 27, 2014. Cited on p. 32, 801, 1005

[[1915](#_bookmark0)] Wronski, Bartlomiej, “Bokeh Depth of Field—Going Insane! Part 1,” *Bart Wronski* blog,

Apr. 7, 2014. Cited on p. 531

[[1916](#_bookmark0)] Wronski, Bartlomiej, “Temporal Supersampling pt. 2—SSAO Demonstration,” *Bart Wronski*

blog, Apr. 27, 2014. Cited on p. 462

[[1917](#_bookmark0)] Wronski, Bartlomiej, “Volumetric Fog: Uniﬁed Compute Shader-Based Solution to Atmo- spheric Scattering,” *SIGGRAPH Advances in Real-Time Rendering in Games course*, Aug. 2014. Cited on p. 610, 611

[[1918](#_bookmark0)] Wronski, Bartlomiej, “Designing a Next-Generation Post-Eﬀects Pipeline,” *Bart Wronski*

blog, Dec. 9, 2014. Cited on p. 514, 520, 527, 543

[[1919](#_bookmark0)] Wronski, Bartlomiej, “Anamorphic Lens Flares and Visual Eﬀects,” *Bart Wronski* blog, Mar.

9, 2015. Cited on p. 526

[[1920](#_bookmark0)] Wronski, Bartlomiej, “Fixing Screen-Space Deferred Decals,” *Bart Wronski* blog, Mar. 12, 2015. Cited on p. 889, 890

[[1921](#_bookmark0)] Wronski, Bartlomiej, “Localized Tonemapping—Is Global Exposure and Global Tonemapping Operator Enough for Video Games?,” *Bart Wronski* blog, Aug. 29, 2016. Cited on p. 286

[[1922](#_bookmark0)] Wronski, Bartlomiej, “Cull That Cone! Improved Cone/Spotlight Visibility Tests for Tiled and Clustered Lighting,” *Bart Wronski* blog, Apr. 13, 2017. Cited on p. 901

[[1923](#_bookmark0)] Wronski, Bartlomiej, “Separable Disk-Like Depth of Field,” *Bart Wronski* blog, Aug. 6, 2017.

Cited on p. 518

[[1924](#_bookmark0)] Wu, Kui, and Cem Yuksel, “Real-Time Fiber-Level Cloth Rendering,” *Symposium on Inter- active 3D Graphics and Games*, Mar. 2017. Cited on p. 359

[[1925](#_bookmark0)] Wu, Kui, Nghia Truong, Cem Yuksel, and Rama Hoetzlein, “Fast Fluid Simulations with Sparse Volumes on the GPU,” *Computer Graphics Forum*, vol. 37, no. 1, pp. 157–167, 2018.

Cited on p. 579

[[1926](#_bookmark0)] Wu, Kui, and Cem Yuksel, “Real-Time Cloth Rendering with Fiber-Level Detail,” *IEEE Transactions on Visualization and Computer Graphics*, to appear. Cited on p. 359

[[1927](#_bookmark0)] Wyman, Chris, “Interactive Image-Space Refraction of Nearby Geometry,” in *GRAPHITE 2005*, ACM, pp. 205–211, Nov. 2005. Cited on p. 630, 632

[[1928](#_bookmark0)] Wyman, Chris, “Interactive Refractions and Caustics Using Image-Space Techniques,” in Wolfgang Engel, ed., *ShaderX*5, Charles River Media, pp. 359–371, 2006. Cited on p. 632

[[1929](#_bookmark0)] Wyman, Chris, “Hierarchical Caustic Maps,” in *Proceedings of the 2008 Symposium on In- teractive 3D Graphics and Games*, ACM, pp. 163–172, Feb. 2008. Cited on p. 632

[[1930](#_bookmark0)] Wyman, C., R. Hoetzlein, and A. Lefohn, “Frustum-Traced Raster Shadows: Revisiting Ir- regular Z-Buﬀers,” in *Proceedings of the 19th Symposium on Interactive 3D Graphics and Games*, ACM, pp. 15–23, Feb.–Mar. 2015. Cited on p. 261, 1001

[[1931](#_bookmark0)] Wyman, Chris, “Exploring and Expanding the Continuum of OIT Algorithms,” in *Proceedings of High-Performance Graphics*, Eurographics Association, pp. 1–11, June 2016. Cited on p. 156, 159, 165

[[1932](#_bookmark0)] Wyman, Chris, Rama Hoetzlein, and Aaron Lefohn, “Frustum-Traced Irregular Z-Buﬀers: Fast, Sub-pixel Accurate Hard Shadows,” *IEEE Transactions on Visualization and Computer Graphics*, vol. 22, no. 10, pp. 2249–2261, Oct. 2016. Cited on p. 261

[[1933](#_bookmark0)] Wyman, Chris, and Morgan McGuire, “Hashed Alpha Testing,” *Symposium on Interactive 3D Graphics and Games*, Mar. 2017. Cited on p. 206, 208, 642

[[1934](#_bookmark0)] Wyszecki, Gu¨nther, and W. S. Stiles, *Color Science: Concepts and Methods, Quantitative Data and Formulae*, Second Edition, John Wiley & Sons, Inc., 2000. Cited on p. 276, 291

[[1935](#_bookmark0)] Xia, Julie C., Jihad El-Sana, and Amitabh Varshney, “Adaptive Real-Time Level-of-Detail- Based Rendering for Polygonal Objects,” *IEEE Transactions on Visualization and Computer Graphics*, vol. 3, no. 2, pp. 171–183, June 1997. Cited on p. 772

[[1936](#_bookmark0)] Xiao, Xiangyun, Shuai Zhang, and Xubo Yang, “Real-Time High-Quality Surface Rendering for Large Scale Particle-Based Fluids,” *Symposium on Interactive 3D Graphics and Games*,

Mar. 2017. Cited on p. 572, 753

[[1937](#_bookmark0)] Xie, Feng, and Jon Lanz, “Physically Based Shading at DreamWorks Animation,” *SIG- GRAPH Physically Based Shading in Theory and Practice course*, Aug. 2017. Cited on p. 336, 359, 364

[[1938](#_bookmark0)] Xu, Ke, “Temporal Antialiasing in *Uncharted 4*,” *SIGGRAPH Advances in Real-Time Ren- dering in Games course*, July 2016. Cited on p. 142, 143, 144, 492

[[1939](#_bookmark0)] Xu, Kun, Yun-Tao Jia, Hongbo Fu, Shimin Hu, and Chiew-Lan Tai, “Spherical Piecewise Constant Basis Functions for All-Frequency Precomputed Radiance Transfer,” *IEEE Trans- actions on Visualization and Computer Graphics*, vol. 14, no. 2, pp. 454–467, Mar.–Apr. 2008.

Cited on p. 402

[[1940](#_bookmark0)] Xu, Kun, Wei-Lun Sun, Zhao Dong, Dan-Yong Zhao, Run-Dong Wu, and Shi-Min Hu, “Aniso- tropic Spherical Gaussians,” *ACM Transactions on Graphics*, vol. 32, no. 6, pp. 209:1–209:11, 2013. Cited on p. 398, 498

[[1941](#_bookmark0)] Yan, Ling-Qi, and Haˇsan, Miloˇs, Wenzel Jakob, Jason Lawrence, Steve Marschner, and Ravi Ramamoorthi, “Rendering Glints on High-Resolution Normal-Mapped Specular Surfaces,” *ACM Transactions on Graphics (SIGGRAPH 2014)*, vol. 33, no. 4, pp. 116:1–116:9, July

2014. Cited on p. 372

[[1942](#_bookmark0)] Yan, Ling-Qi, Miloˇs Haˇsan, Steve Marschner, and Ravi Ramamoorthi, “Position-Normal Dis- tributions for Eﬃcient Rendering of Specular Microstructure,” *ACM Transactions on Graph- ics (SIGGRAPH 2016)*, vol. 35, no. 4, pp. 56:1–56:9, July 2016. Cited on p. 372

[[1943](#_bookmark0)] Yang, Baoguang, Zhao Dong, Jieqing Feng, Hans-Peter Seidel, and Jan Kautz, “Variance Soft Shadow Mapping,” *Computer Graphics Forum*, vol. 29, no. 7, pp. 2127–2134, 2010. Cited on p. 257, 259

[[1944](#_bookmark0)] Yang, Lei, Pedro V. Sander, and Jason Lawrence, “Geometry-Aware Framebuﬀer Level of De- tail,” in *Proceedings of the Nineteenth Eurographics Symposium on Rendering*, Eurographics Association, pp. 1183–1188, June 2008. Cited on p. 520

[[1945](#_bookmark0)] Yang, L., Y.-C. Tse, P. Sander, J. Lawrence, D. Nehab, H. Hoppe, and C. Wilkins, “Image- Space Bidirectional Scene Reprojection,” *ACM Transactions on Graphics*, vol. 30, no. 6, pp. 150:1–150:10, 2011. Cited on p. 523

[[1946](#_bookmark0)] Yang, L., and H. Bowles, “Accelerating Rendering Pipelines Using Bidirectional Iterative Reprojection,” *SIGGRAPH Advances in Real-Time Rendering in Games course*, Aug. 2012.

Cited on p. 523

[[1947](#_bookmark0)] Ylitie, Henri, Tero Karras, and Samuli Laine, “Eﬃcient Incoherent Ray Traversal on GPUs Through Compressed Wide BVHs,” *High Performance Graphics*, July 2017. Cited on p. 511

[[1948](#_bookmark0)] Yoon, Sung-Eui, Peter Lindstrom, Valerio Pascucci, and Dinesh Manocha, “Cache-Oblivious Mesh Layouts,” *ACM Transactions on Graphics*, vol. 24, no. 3, pp. 886–893, July 2005. Cited on p. 828

[[1949](#_bookmark0)] Yoon, Sung-Eui, and Dinesh Manocha, “Cache-Eﬃcient Layouts of Bounding Volume Hierar- chies,” *Computer Graphics Forum*, vol. 25, no. 3, pp. 853–857, 2006. Cited on p. 828

[[1950](#_bookmark0)] Yoon, Sung-Eui, Sean Curtis, and Dinesh Manocha, “Ray Tracing Dynamic Scenes Using Selective Restructuring,” in *18th Eurographics Symposium on Rendering*, Eurographics Asso- ciation, pp. 73–84, June 2007. Cited on p. 821

[[1951](#_bookmark0)] Yoshida, Akiko, Matthias Ihrke, Rafa-l Mantiuk, and Hans-Peter Seidel, “Brightness of the Glare Illusion,” *Proceeding of the 5th Symposium on Applied Perception in Graphics and Visualization*, ACM, pp. 83–90, Aug. 2008. Cited on p. 524

[[1952](#_bookmark0)] Yu, X., R. Wang, and J. Yu, “Real-Time Depth of Field Rendering via Dynamic Light Field Generation and Filtering,” *Computer Graphics Forum*, vol. 29, no. 7, pp. 2009–2107, 2010.

Cited on p. 523

[[1953](#_bookmark0)] Yuksel, Cem, and John Keyser, “Deep Opacity Maps,” *Computer Graphics Forum*, vol. 27, no. 2, pp. 675–680, 2008. Cited on p. 257, 645, 646

[[1954](#_bookmark0)] Yuksel, Cem, and Sara Tariq, *SIGGRAPH Advanced Techniques in Real-Time Hair Rendering and Simulation course*, July 2010. Cited on p. 45, 642, 646, 649

[[1955](#_bookmark0)] Yuksel, Cem, “Mesh Color Textures,” in *High Performance Graphics 2017*, Eurographics Association, pp. 17:1–17:11, 2017. Cited on p. 191

[[1956](#_bookmark0)] Yusov, E., “Real-Time Deformable Terrain Rendering with DirectX 11,” in Wolfgang Engel, ed., *ShaderX*3, Charles River Media, pp. 13–39, 2004. Cited on p. 879

[[1957](#_bookmark0)] Yusov, Egor, “Outdoor Light Scattering,” *Game Developers Conference*, Mar. 2013. Cited on p. 615

[[1958](#_bookmark0)] Yusov, Egor, “Practical Implementation of Light Scattering Eﬀects Using Epipolar Sampling and 1D Min/Max Binary Trees,” *Game Developers Conference*, Mar. 2013. Cited on p. 608

[[1959](#_bookmark0)] Yusov, Egor, “High-Performance Rendering of Realistic Cumulus Clouds Using Pre-computed Lighting,” in *Proceedings of the Eurographics / ACM SIGGRAPH Symposium on High Per- formance Graphics*, Eurographics Association, pp. 127–136, Aug. 2014. Cited on p. 617, 618

[[1960](#_bookmark0)] Zakarin, Jordan, “How *The Jungle Book* Made Its Animals Look So Real with Groundbreaking VFX,” *Inverse.com*, Apr. 15, 2016. Cited on p. 1042

[[1961](#_bookmark0)] Zarge, Jonathan, and Richard Huddy, “Squeezing Performance out of Your Game with ATI Developer Performance Tools and Optimization Techniques,” *Game Developers Conference*,

Mar. 2006. Cited on p. 713, 786, 787

[[1962](#_bookmark0)] Zhang, Fan, Hanqiu Sun, Leilei Xu, and Kit-Lun Lee, “Parallel-Split Shadow Maps for Large- Scale Virtual Environments,” in *Proceedings of the 2006 ACM International Conference on Virtual Reality Continuum and Its Applications*, ACM, pp. 311–318, June 2006. Cited on p. 242, 244

[[1963](#_bookmark0)] Zhang, Fan, Hanqiu Sun, and Oskari Nyman, “Parallel-Split Shadow Maps on Programmable GPUs,” in Hubert Nguyen, ed., *GPU Gems 3*, Addison-Wesley, pp. 203–237, 2007. Cited on p. 242, 243, 244

[[1964](#_bookmark0)] Zhang, Fan, Alexander Zaprjagaev, and Allan Bentham, “Practical Cascaded Shadow Maps,” in Wolfgang Engel, ed., *ShaderX*7, Charles River Media, pp. 305–329, 2009. Cited on p. 242, 245

[[1965](#_bookmark0)] Zhang, Hansong, *Effective Occlusion Culling for the Interactive Display of Arbitrary Models*, PhD thesis, Department of Computer Science, University of North Carolina at Chapel Hill,

July 1998. Cited on p. 843

[[1966](#_bookmark0)] Zhang, Long, Qian Sun, and Ying He, “Splatting Lines: An Eﬃcient Method for Illustrating 3D Surfaces and Volumes,” in *Proceedings of the 18th Meeting of the ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games*, ACM, pp. 135–142, Mar. 2014. Cited on p. 665

[[1967](#_bookmark0)] Zhao, Guangyuan, and Xianming Sun, “Error Analysis of Using Henyey-Greensterin in Monte Carlo Radiative Transfer Simulations,” *Electromagnetics Research Symposium*, Mar. 2010.

Cited on p. 598

[[1968](#_bookmark0)] Zhdan, Dmitry, “Tiled Shading: Light Culling—Reaching the Speed of Light,” *Game Devel- opers Conference*, Mar. 2016. Cited on p. 894

[[1969](#_bookmark0)] Zhou, Kun, Yaohua Hu, Stephen Lin, Baining Guo, and Heung-Yeung Shum, “Precomputed Shadow Fields for Dynamic Scenes,” *ACM Transactions on Graphics (SIGGRAPH 2005)*, vol. 24, no. 3, pp. 1196–1201, 2005. Cited on p. 466

[[1970](#_bookmark0)] Zhukov, Sergei, Andrei Iones, and Grigorij Kronin, “An Ambient Light Illumination Model,” in *Rendering Techniques ’98*, Springer, pp. 45–56, June–July 1998. Cited on p. 449, 454, 457

[[1971](#_bookmark0)] Zink, Jason, Matt Pettineo, and Jack Hoxley, *Practical Rendering & Computation with Di- rect3D 11*, CRC Press, 2011. Cited on p. 47, 54, 90, 518, 519, 520, 568, 795, 813, 814,

914

[[1972](#_bookmark0)] Zinke, Arno, Cem Yuksel, Weber Andreas, and John Keyser, “Dual Scattering Approximation for Fast Multiple Scattering in Hair,” *ACM Transactions on Graphics (SIGGRAPH 2008)*, vol. 27, no. 3, pp. 1–10, 2008. Cited on p. 645

[[1973](#_bookmark0)] Zioma, Renaldas, “Better Geometry Batching Using Light Buﬀers,” in Wolfgang Engel, ed.,

*ShaderX*4, Charles River Media, pp. 5–16, 2005. Cited on p. 893

[[1974](#_bookmark0)] Zirr, Tobias, and Anton Kaplanyan, “Real-Time Rendering of Procedural Multiscale Materi- als,” *Symposium on Interactive 3D Graphics and Games*, Feb. 2016. Cited on p. 372

[[1975](#_bookmark0)] Zorin, Denis, Peter Schro¨der, and Wim Sweldens, “Interpolating Subdivision for Meshes with Arbitrary Topology,” in *SIGGRAPH ’96: Proceedings of the 23rd Annual Conference on Computer Graphics and Interactive Techniques*, ACM, pp. 189–192, Aug. 1996. Cited on p. 761

[[1976](#_bookmark0)] Zorin, Denis, *Stationary Subdivision and Multiresolution Surface Representations*, PhD thesis,

CS-TR-97-32, California Institute of Technology, 1997. Cited on p. 759, 761

[[1977](#_bookmark0)] Zorin, Denis, Peter Schr¨oder, Tony DeRose, Leif Kobbelt, Adi Levin, and Wim Sweldens, *SIGGRAPH Subdivision for Modeling and Animation course*, July 2000. Cited on p. 756, 760, 761, 762, 781

[[1978](#_bookmark0)] Zou, Ming, Tao Ju, and Nathan Carr, “An Algorithm for Triangulating Multiple 3D Polygons,”

*Computer Graphics Forum*, vol. 32, no. 5, pp. 157–166, 2013. Cited on p. 685

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